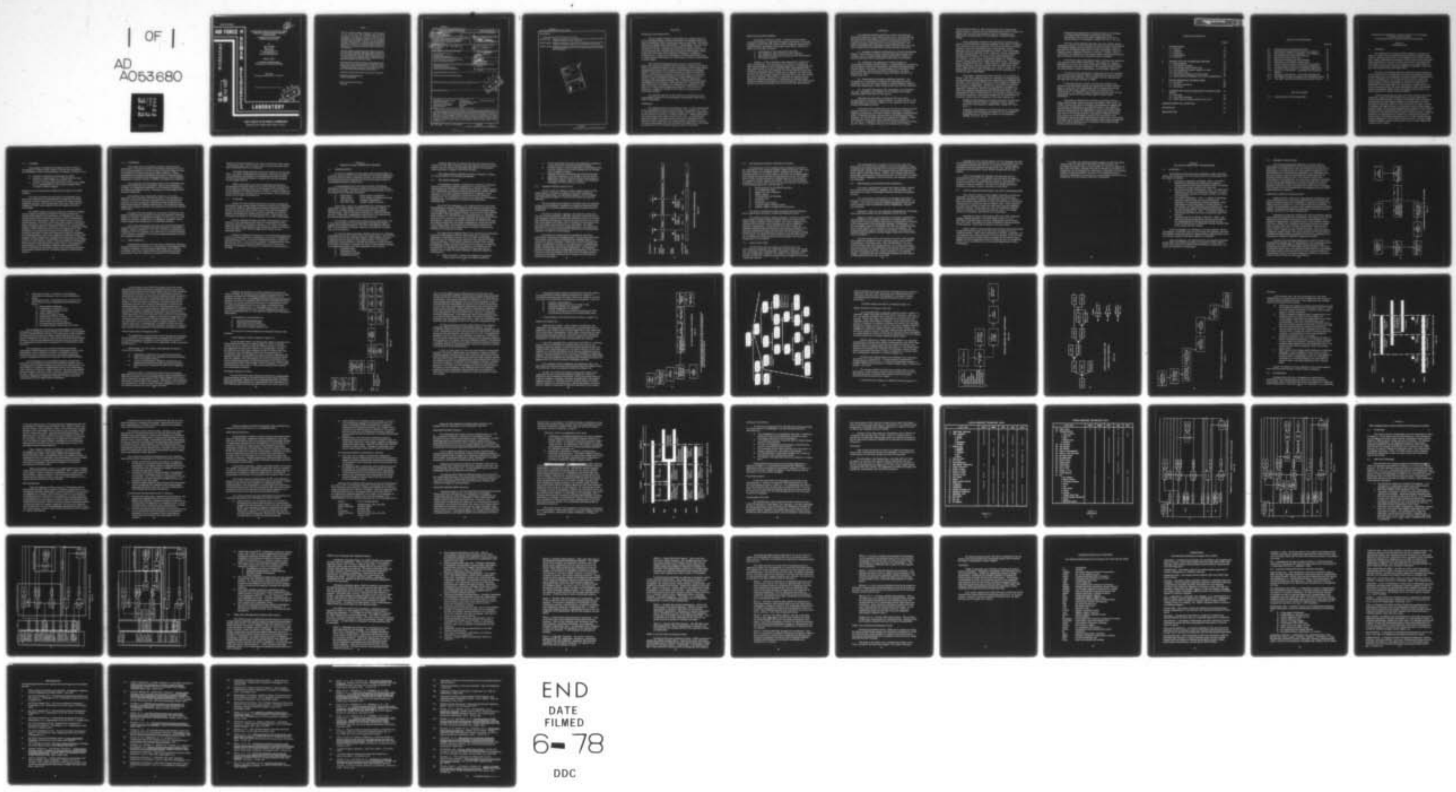
AD-A053 680 DYNAMICS RESEARCH CORP WILMINGTON MASS F/G 5/5
INTEGRATION AND APPLICATION OF HUMAN RESOURCE TECHNOLOGIES IN W--ETC(U)
MAR 78 J C GOCLOWSKI, G F KING, P G RONCO F33615-77-C-0016

UNCLASSIFIED AFHRL-TR-78-6(1) NL

| OF |

AD
A053680



END
DATE
FILMED
6-78
DDC

AFHRL-TR-78-6(I)

AIR FORCE

HUMAN RESOURCES

INTEGRATION AND APPLICATION OF HUMAN RESOURCE TECHNOLOGIES IN WEAPON SYSTEM DESIGN:

COORDINATION OF FIVE HUMAN RESOURCE TECHNOLOGIES

By

John C. Goclowski
Gerard F. King
Paul G. Ronco
Dynamics Research Corporation
60 Concord Street
Wilmington, Massachusetts 01887

William B. Askren

ADVANCED SYSTEMS DIVISION
Wright-Patterson Air Force Base, Ohio 45433

March 1978
Interim Report for Period April 1977 – October 1977

Approved for public release; distribution unlimited

LABORATORY

AIR FORCE SYSTEMS COMMAND
BROOKS AIR FORCE BASE, TEXAS 78235

NOTICE

When U.S. Government drawings, specifications, or other data are used for any purpose other than a definitely related Government procurement operation, the Government thereby incurs no responsibility nor any obligation whatsoever, and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise, as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

This interim report was submitted by Dynamics Research Corporation, 60 Concord Street, Wilmington, Massachusetts 01887, under contract F33615-77-C-0016, project 1959, with Advanced Systems Division, Air Force Human Resources Laboratory (AFSC), Wright-Patterson Air Force Base, Ohio 45433. Dr. William B. Askren, Personnel and Training Requirements Branch, was the work unit scientist.

This report has been reviewed and cleared for open publication and/or public release by the appropriate Office of Information (OI) in accordance with AFR 190-17 and DoDD 5230.9. There is no objection to unlimited distribution of this report to the public at large, or by DDC to the National Technical Information Service (NTIS).

This technical report has been reviewed and is approved for publication.

GORDON A. ECKSTRAND, Director
Advanced Systems Division

DAN D. FULGHAM, Colonel, USAF
Commander

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: AFHRL/TR-78-6[redacted] (1)
2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle): INTEGRATION AND APPLICATION OF HUMAN RESOURCE TECHNOLOGIES IN WEAPON SYSTEM DESIGN: COORDINATION OF FIVE HUMAN RESOURCE TECHNOLOGIES.
5. TYPE OF REPORT & PERIOD COVERED: Interim rept. Apr[redacted] – Octo[redacted]77
6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): John C. Goclowski, William B. Askren, Gerard F. King, Paul G. Ronco
8. CONTRACT OR GRANT NUMBER(s): F33615-77-C-0016 rev
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Dynamics Research Corporation, 60 Concord Street, Wilmington, Massachusetts 01887
10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 63751F, 19590002
11. CONTROLLING OFFICE NAME AND ADDRESS: HQ Air Force Human Resources Laboratory (AFSC), Brooks Air Force Base, Texas 78235
12. REPORT DATE: Mar[redacted]78
13. NUMBER OF PAGES: [redacted] 73 p.
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office): Advanced Systems Division, Air Force Human Resources Laboratory, Wright-Patterson Air Force Base, Ohio 45433
15. SECURITY CLASS. (of this report): Unclassified
15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report): Approved for public release; distribution unlimited.
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)
18. SUPPLEMENTARY NOTES
19. KEY WORDS (Continue on reverse side if necessary and identify by block number):

coordinated human resource technology
design option decision trees
human resource in design trade-offs
instructional system development
job guide development
life cycle costing
maintenance manpower modeling
system ownership costing
task analysis
training
weapon system acquisition

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The five human resource technologies are defined as: maintenance manpower modeling (MMM), instructional system development (ISD), job guide development (JGD), system ownership costing (SOC), and human resources in design trade-offs (HRDT). The interrelationships among the five human resource technologies are identified and a methodology to apply them throughout weapon system acquisition is developed. The methodology, the coordinated human resource technology (CHRT), when applied, quantifies the reliability, maintainability, manpower, training, and job guide documentation requirements for a weapon system and allows these factors to influence design, maintenance, operations, and support concepts early in acquisition. CHRT also provides a means to estimate ownership cost.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified hc

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

388 902

Unclassified
SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

Item 20 Continued:

This document is one volume of a three-volume report, namely:

AFHRL-TR-78-6(I)	Integration and Application of Human Resource Technologies in Weapon System Design: Coordination of Five Human Resource Technologies
AFHRL-TR-78-6(II)	Integration and Application of Human Resource Technologies in Weapon System Design: Processes for the Coordinated Application of the Five Human Resources Technologies
AFHRL-TR-78-6(III)	Integration and Application of Human Resource Technologies in Weapon System Design: Consolidated Data Base Specification for the Coordinated Application of the Five Human Resource Technologies

Unclassified
SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

SUMMARY

PROBLEM AND OBJECTIVE

The five human resource technologies are maintenance manpower modeling (MMM), instructional system development (ISD), job guide development (JGD), system ownership costing (SOC), and human resources in design trade-offs (HRDT). Traditionally, they have been applied individually at various times during the weapon system acquisition process. Although one intuitively recognizes similarities in activities and data requirements among these technologies, these similarities had never been confirmed, explored, or exploited. Furthermore, it appears that exploitation of these similarities early in weapon system acquisition may allow human resource considerations to affect design.

The Advanced Systems Division of the Air Force Human Resources Laboratory (AFHRL) has, therefore, initiated a two-phase effort to integrate and apply the five technologies to the weapon system acquisition process as the coordinated human resource technology (CHRT). This volume is one of three which documents the Phase I effort. The objective of this phase was twofold. One, to develop and integrate the relationships among the five technologies in order to create a totally coordinated technology, CHRT, for application throughout the acquisition process. Two, to determine the data input requirements and to prepare a specification for a consolidated data base (CDB) which will support the integration and application of the CHRT in a weapon system application program. The objective of Phase II is to apply the results of this study to a weapon system acquisition program.

The specific objective of this volume is to develop the interrelationships among the five technologies and generally describe the CHRT methodology.

APPROACH

The approach taken was as follows. First, a total understanding of the technologies and their characteristics was developed by a team of researchers well versed in weapon system acquisition, engineering, and the behavioral sciences. Personal experience, existing literature, and interviewing were used as source data. Next, the interrelationships and similar data requirements among the technologies were identified without relating to the weapon system acquisition time line. The interrelationships were then developed for application in all phases of acquisition as the coordinated human resource technology.

RESULTS AND CONCLUSIONS

This effort resulted in CHRT, a predictive and product-oriented methodology, applicable throughout acquisition. It has the capability to affect not only weapon system design but also selection of maintenance, operations, and support approaches. Integral to CHRT are four basic activities:

1. Development of the consolidated data base
2. The integrated requirements and task analysis
3. Instructional system and job guide product development
4. The impact analysis

Briefly, a CDB is developed and maintained to service the CHRT methodology. The CDB data is then used for an integrated requirements analysis which quantifies operations, maintenance, and task requirements in terms of reliability ($\overline{R}$), maintainability ($\overline{M}$), manpower, and scope and magnitude of the instructional system and job guide development effort. These factors together with associated cost data for any specific design are then provided to the user through the impact analysis. CHRT may be reiterated to evaluate various design and support approaches. A traditional but integrated task analysis is performed during full scale development. The instructional system and job guide products are derived from this task analysis.

PREFACE

The Advanced Systems Division of the Air Force Human Resources Laboratory has initiated project 1959, Advanced System for Human Resources Support of Weapon Systems Development, to demonstrate the technical feasibility of methodologies geared to reduce the system ownership cost of new weapon systems. The Advanced Medium STOL Transport (AMST) is being used as the test case. Project 1959 is divided into the following four work units.

01 - Analysis of Resource Utilization of a Present Operational System - Data related to human resource utilization and life cycle costing (LCC) on a similar past weapon system (the C-130E) is gathered and presented. Availability of such data is determined.

02 - Integration and Application of Human Resource Technologies in Weapon System Design - A methodology for integrating the five human resource technologies is developed and subsequently demonstrated on the AMST. The technologies are maintenance manpower modeling, instructional system development, job guide development, system ownership costing, and human resources in design trade-offs.

03 - Maintenance Personnel Availability Analysis - The development of a technique to estimate the availability of human resources over time and of procedures to align availability expectations with requirements. AMST requirements data will be considered.

04 - Personnel Subsystem Test, Evaluation, and Validation - The test, evaluation, and validation of the results of the studies conducted under work units 01, 02, and 03.

Although this total effort is presently directed toward demonstration on a specific weapon system, it is expected that it will be applicable to any system, military or non-military, and to major system modifications as well.

This study which represents work unit 02 was performed under contract F33615-77-C-0016 by the Systems Division of Dynamics Research Corporation, 60 Concord Street, Wilmington, Massachusetts 01887. Technical direction was provided by the Advanced Systems Division, Air Force Human Resources Laboratory (AFHRL), Wright-Patterson Air Force Base, Ohio. Appreciation is extended to Dr. Gordon A. Eckstrand, Director of the Advanced Systems Division and Dr. Ross L. Morgan, Chief of the Personnel and Training

Requirements Branch for their contributions and encouragement. Major Duncan L. Dieterly was the project director and Dr. William B. Askren was the work unit scientist on unit 02, Integration and Application of Human Resource Technologies in Weapon System Design.

Many individuals throughout the Department of Defense and industry contributed their ideas and opinions to this effort. Of special note, however, were the members of the Advanced Systems Division Advisory Team who contributed both in their specific areas of expertise and in the total development of CHRT. These individuals and their areas of expertise are Mr. Robert N. Deem, maintenance manpower modeling; Dr. Garry A. Klein, instructional system development; Dr. Donald L. Thomas, job guide development; Mr. Harry A. Baran, system ownership costing; Dr. William B. Askren, human resources in design trade-offs; and Dr. Lawrence E. Reed, consolidated data base. Major Robert J. Pucik of the AMST Program Office provided the interface with the AMST acquisition effort. Appreciation is also extended to Dr. John P. Foley, Jr., for sharing his view of job guide development and the instructional system/job guide relationship.

This report, consisting of three volumes, is the product of Phase I. The three volumes contain the rationale for integrating the human resources technologies and the methodology for applying them as CHRT. They show how CHRT can be used to influence design and the selection of maintenance, operations, and support alternatives. The evolution of CHRT from elements of existing technologies is discussed. Additionally, specific descriptions are provided of the CDB, the integrated requirements and task analysis (IRTA), the development of ISD and JGD products, and the impact analysis which allows the evaluation of alternative designs and the identification of excessive human resource utilization. The three volumes are:

> Integration and Application of Human Resource Technologies in Weapon System Design: Coordination of Five Human Resource Technologies for Application, AFHRL-TR-78-6, Vol. I;
>
> Integration and Application of Human Resource Technologies in Weapon System Design: Processes for the Coordinated Application of the Five Human Resource Technologies, AFHRL-TR-78-6, Vol. II;

Integration and Application of Human Resource Technologies in Weapon System Design: Consolidated Data Base Specification for the Coordinated Application of the Five Human Resource Technologies, AFHRL-TR-78-6, Vol. III.

The first volume initially describes the basic weapon system acquisition process. It then discusses the human resource technologies as presently applied and their interfaces with each other. Next the potential for an expanded application of these technologies within the weapon system acquisition process is described. Finally, CHRT is described as an integration of the human resource technology elements and its proposed role in each acquisition phase is detailed.

The second volume describes the basic activities and associated data inherent in the CHRT methodology. This volume is a detailed expansion of the first. The major processes of CHRT are defined as the consolidated data base development, the integrated requirements and task analysis, product development, and the impact analysis.

The third volume specifies the requirements for the consolidated data base which supports CHRT. It describes the input and output data, the associated sources, the processes, and the interfaces of the CDB with the major process of CHRT.

It should be noted, however, that this total report is the product of the development phase and represents the CHRT methodology as conceived. The methodology will be demonstrated during Phase II and this report updated to reflect the results of the demonstration. The updated version therefore will describe a proven methodology which can be practically applied during system acquisition.

Stimulated by Department of Defense intensitifed efforts to reduce future weapon system operating and support (O&S) costs, the AFHRL initiated this study to develop a methodology for applying the five primary technologies in an integrated fashion. The results of this first phase indicate that application of a new coordinated human resource technology has the potential for significantly reducing the O&S costs of new weapon systems. Examples of additional benefits that accrue are: (a) synergistic effects of the interaction of the technologies regarding improving personnel performance and reducing personnel costs, (b) potential cost savings through single management of the five HR technologies, and (c) potential cost savings through sharing common data sources.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

Integration and Application of Human Resource Technologies in Weapon System Design: Coordination of Five Human Resource Technologies

Section 1
INTRODUCTION

1.1 GENERAL

The Department of Defense (DOD) continues to intensify its efforts to reduce future weapon system operating and support (O&S) costs by requiring each service to incorporate cost-saving measures and to make a quantitative assessment of O&S costs for new programs under development. The services have been asked to establish O&S cost targets for each system in development and to apply design-to-cost trade-off procedures that give additional emphasis to O&S costs as a key element in the trade-off process.

The Air Force Human Resource Laboratory has developed or has contributed to the development of the five technologies described in this report which are applicable in implementing this DOD guidance. These technologies have a similar objective, namely; improving personnel performance and manpower utilization in maintenance, ground support, and air operations as well as reducing cost of ownership. These technologies are specifically: maintenance manpower modeling (MMM), job guide development (JGD), instructional system development (ISD), system ownership costing (SOC), and human resources in design trade-offs (HRDT).

These technologies generally have been developed and tested separately. Each has shown definite value in improving weapon system cost/effectiveness. In support of AFHRL's effort to expand the application of these human resources technologies, Dynamics Research Corporation (DRC) has been contracted to define a method to integrate and apply them in a coordinated manner during weapon system design. This coordinated application is called the Coordinated Human Resource Technology (CHRT) and is believed to have a real potential in reducing O&S costs for future weapon systems. Additional benefits to be anticipated from CHRT are: (a) improved personnel performance, (b) reduced personnel costs, (c) cost savings through single management of five human resource efforts, (d) cost savings through sharing a common data source, and (e) a more supportable weapon system design.

1.2 PURPOSE

The program to integrate and apply the human resource technologies in weapon system design is divided into two phases: (a) development, and (b) demonstration. The purpose of Phase I is to:

- Develop an integrated methodology for CHRT
- Generate a specification for a consolidated data base (CDB) from which CHRT will operate, and
- Provide a demonstration plan which will show how CHRT can be demonstrated on the Advanced Medium STOL Transport (AMST) program.

Phase II is the demonstration of CHRT and the CDB on the AMST program.

This report develops and describes a methodology which facilitates continuous and comprehensive consideration of human resources and their associate cost throughout the weapon system acquisition process. More specifically, this report describes the synthesis of CHRT from elements of the five human resources technologies.

The CHRT predicts the human resources required to support various design and support alternatives through an integrated requirements analysis. This prediction accomplished in a timely manner allows human resources to become a real consideration in evaluating these alternatives. CHRT also allows one to review an existing design to determine areas which place excessive demand on human resources, thus indicating a possible need for an alternative design or support approach. Included in CHRT is an ownership costing capability which allows the human resource requirement for any alternative to be evaluated for impact on ownership cost. This predictive capability is especially important during the conceptual and validation phases where such capability is presently lacking. The results of CHRT during these two phases also contribute to specific products of those phases: the personnel and training concept and plan and the tech data concept and plan. During the full scale development, CHRT becomes largely product oriented. This is accomplished by transitioning to an on-equipment integrated task analysis which becomes the basis for the actual content of the instructional system and job guide products and for a detailed manpower requirements analysis.

1.3 AUTHORITY

The weapon system acquisition process requires that an assessment of technical response to operational requirements, life cycle cost parameters, and a broad range of logistic support factors be available for decision-making and option evaluation. These assessments are required throughout all phases of acquisition and specifically at Defense System Acquisition Review Council (DSARC) Milestones or similar reviews, if DSARC oversight is not required.

The initial base for assessment early in the acquisition cycle is primarily historical data and generic system and operational concepts. As acquisition progresses, a more specific definition of the system and support evolves, resulting in an increasingly mature base for assessment.

The validity of any assessment, however, is not only dependent on the maturity of its base but also on the identification, accuracy, and correct interface representation of the parameters involved. In order to properly characterize these parameters and thus provide valid and realistic assessments, the integrated logistic support (ILS) program and life cycle costing (LCC) have been initiated within DOD.

The goal of the ILS program is to provide a composite of all support considerations necessary to assure the effective economical support of a system or equipment throughout its life cycle. It is also intended to provide a single source of validated, integrated design-related logistic data pertaining to an acquisition program.

Life cycle costing makes use of the data provided through the acquisition process to estimate ownership (operation, maintenance, support, training, manpower, etc.) cost, as well as development and acquisition cost. The purpose of this estimate is to provide visibility to the economic advantages of the various design/development options and acquisition decisions.

1.4 APPLICABILITY

Considerable progress has been made in effectively characterizing the parameters necessary for projecting and assessing the effect of design on support, various support approaches, and resulting ownership costs. There remains room for improvement however. Specifically a need for methods and techniques which adequately

identify the interfaces between cost drivers and predict their impact on ownership costs. There is also a need to devise products which allow these predictions to be achieved.

The methodology presented herein is intended to fill this dual need. The CHRT, when applied as described, will improve assessment capability in all phases of the acquisition life cycle and will provide a coordinated personnel, training, and tech data program for the design selected.

CHRT is intended to both aid in identifying and selecting alternatives during each phase and to provide critical decision data to the DSARC or similar review at the completion of each phase. It is also intended that CHRT provide the means to develop an effective and compatible mix and quality of the two products, the instructional system and job guide documentation.

1.5 OVERVIEW

Section 2 of this volume provides the necessary background information on the weapon system acquisition process and establishes the need for CHRT by identifying some present information requirements of the process which cannot be met with existing techniques. Section 3 describes each human resource technology as presently applied and develops the interfaces among them. This volume then concludes with Section 4, the development of the CHRT methodology.

Section 4 initially develops the CHRT methodology from the elements of the individual human resource technologies and their associated interfaces developed in Section 3. The major processes within the CHRT methodology are also identified. Section 4 concludes with a discussion of the specific application of CHRT in each acquisition phase.

Volume II subtitled "Processes for the Coordinated Application of the Five Human Resource Technologies" is the key to developing an understanding of CHRT. There the processes inherent in CHRT are discussed in detail. A third volume subtitled "Consolidated Data Base Specification for the Coordinated Application of the Five Human Resource Technologies" then goes on to specify the requirements of the CDB.

Section 2
WEAPON SYSTEM ACQUISITION PROCESS

2.1 REQUIREMENTS

In order to integrate the five human resource technologies in a manner that will result in the most effective coordinated application during the weapon system acquisition process, one must understand the acquisition process requirements and how the human resource technologies function in relation to it.

A comprehensive list of the more pertinent information available on the weapons system acquisition process is provided in the reference section. The basic process and requirements, however, are defined by the following documents:

• DoDD 5000.1	Major System Acquisitions
• DoDD 5000.2	Major System Acquisition Process
• AFLCM 800-1	Program Management
• MIL-STD-1388	Logistic Support Analysis

DoDD 5000.1 places the responsibility for development and acquisition of major defense systems on the proponent military department or defense agency and identifies four key program decision points. This is discussed in Section 2.2 under the DSARC process. DoDD 5000.2 supplements DoDD 5000.1 with policies and procedures supporting the decision-making process.

AFLCM 800-1 describes the weapon system acquisition cycle in detail and establishes the requirements for integrated logistic support (ILS) during acquisition. MIL-STD-1388 supports AFLCM 800-1 and describes the analysis required to provide the necessary data for ILS definition.

A review of these documents indicates that there is a standard acquisition process with typical events and requirements. This process is then tailored to each individual weapon system making the actual acquisition process unique to each weapon system. The specific phases may be accelerated or extended with specific actions omitted or modified. Basically, the speed with which a system passes through the acquisition process is directly dependent on four factors:

- Available funds
- Operational need
- Complexity of design
- Program advocacy

Program advocacy is included with the other obvious factors because it is the effort required to provide DOD and service decision-makers with the concise and quantified description of the program status necessary to support a go-ahead decision.

The weapon system acquisition process is depicted in Figure 2-1 and discussed in the following paragraphs.

2.2 THE DSARC PROCESS

An acquisition program is initiated by a Secretary of Defense decision authorizing a military department to proceed with the identification and evaluation of alternatives to satisfy a stated mission need. Subsequent to program initiation (Milestone 0), DSARC reviews are keyed to the major decision milestones of a program. These milestones mark the beginning of demonstration and validation (Milestone I), the commitment of resources to full-scale development (Milestone II), and initiation of production and deployment (Milestone III).

On an Air Force program, LCC evaluation starts with initial R&D funding for advanced development which permits execution of the conceptual phase. Milestone I marks the end of the conceptual phase and the beginning of the validation phase. It is the first major financial commitment to the development. In some programs, the validation phase consists of a "fly-off" between competing advanced development aircraft and the selection of a single contractor for engineering development. Approval at Milestone II initiates the full scale development phase during which the design configuration and characteristics of the weapon system are tailored to the operational needs of the military department. When engineering is complete, Milestone III addresses the production decision.

The operating and support phase of an aircraft's life essentially starts with deployment of the first operational units, well after completion of the DSARC reviews. Yet, the major determinants of O&S costs are the decisions made during the early phases of weapon system acquisition. DOD requires analysis of outyear costs during development, design, and procurement with the objective of reducing the allocation for the operation and support of the weapon system. Consequently, an analysis of acquisition and ownership costs is required at each major decision milestone to assist the DSARC in verifying that:

- DOD can afford to operate and support the proposed weapon system once it is in the defense inventory

- Future ownership costs have been adequately considered in the selection of the proposed weapon system
- Positive action to reduce acquisition and ownership costs has been initiated in the system design and the development of support concepts
- Relevant historical ownership cost drivers have been explicitly considered in the design of the new system
- Significant trade-offs between cost and performance of alternative designs, support concepts, and acquisition strategies have been taken into account.

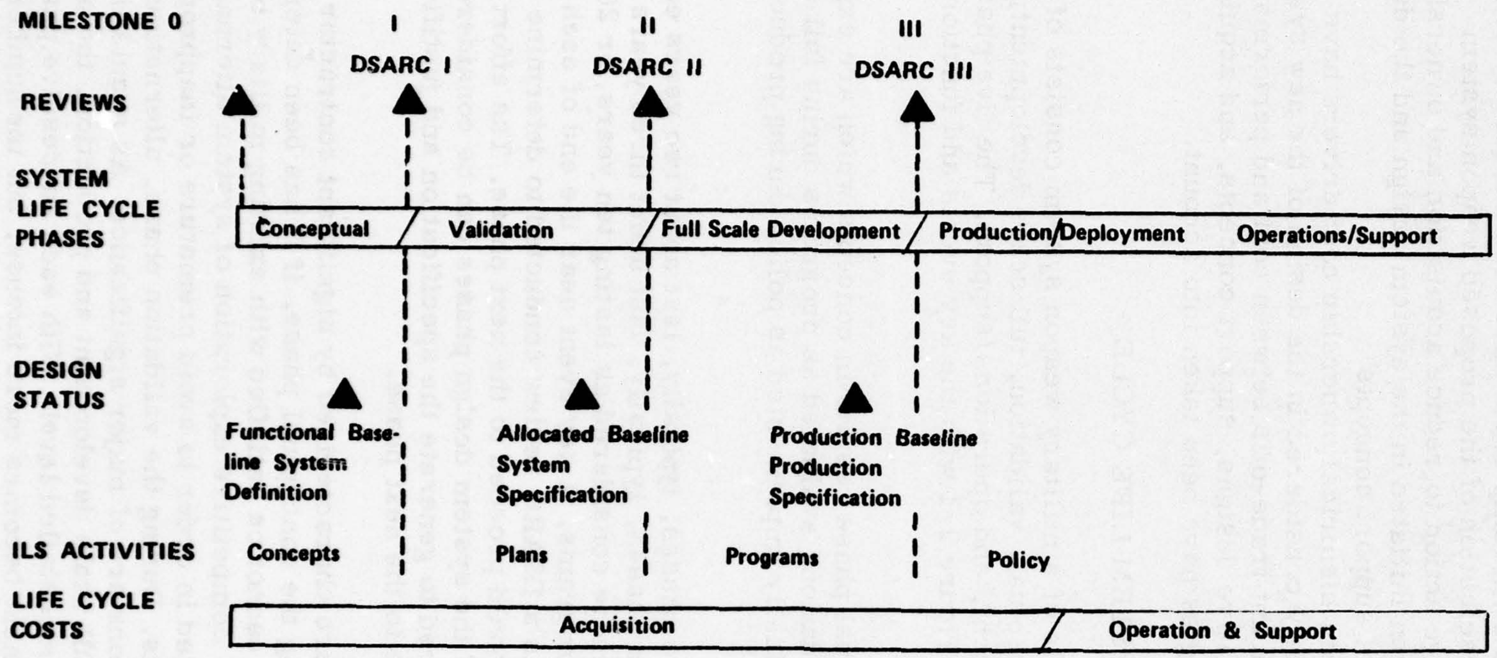
2.3 WEAPON SYSTEM LIFE CYCLE

The life cycle of a military weapon system consists of five major phases: conceptual, validation, full scale development, production/deployment, and operations/support. The five phases were illustrated in Figure 2-1 with the key events and functions identified.

The conceptual phase results in concepts which are expanded to plans during validation, evaluated as programs during full scale development, and finally implemented as policy during production/deployment.

The first two phases, typically, last about two years each. The third and fourth phases, typically, last about three years each. The last phase might be considered as lasting ten years, or 20 years with modification programs. A key event near the end of each of the first three phases is a DSARC review conducted to determine if and how the program should proceed to the next phase. The effort expended in each of the system design phases can be considered as that which is required to generate the specification and justification required to advance to the next phase.

All phases are characterized by significant contractor involvement. During the conceptual phase, if it has been determined that mission needs cannot be satisfied with existing military or commercial items, competitive exploration of system alternatives should be emphasized in order to avoid premature or inappropriate design commitments. During the validation phase, alternative subsystem considerations are of major significance. As acquisition proceeds through full scale development and production, the alternatives are at the more detailed level. With each successive phase, contractor involvement becomes more intense, but the number of contractors decreases.



WEAPON SYSTEM ACQUISITION PROCESS

Figure 2-1

2.4 INTEGRATED LOGISTIC SUPPORT CONCEPT

An integral part of the weapon system acquisition process is the development of its integrated logistic support elements. This calls for action during the conceptual phase to integrate all elements affecting support of the weapon system, such that the resulting support and training concepts mesh with the operational concept. The refinement of these concepts during the validation phase is documented in the integrated logistic support plan (ILSP). This plan can be updated throughout the system life cycle and becomes the primary data source in the following areas (ref. AFLCM 800-1):

1. Maintainability and reliability interface
2. The maintenance plan
3. Support and test equipment
4. Supply support
5. Transportation and handling
6. Technical data
7. Facilities
8. Personnel and training
9. Logistic support resource funds
10. Logistic support management information

The ILSP is developed in depth during full scale development and is implemented during the production/deployment phase.

The integrated logistic support program, in theory, is provided data through the logistic support analysis (LSA) and its associated logistic support analysis record (LSAR). The LSA is supposed to be conducted on an iterative basis throughout the entire acquisition process. Unfortunately, its structure is such that it cannot be adequately initiated until detailed-level data become available in the full scale development phase. System-level information must be obtained earlier in the acquisition process but the technique for doing so is lacking. The CHRT process is planned to fill this need during the conceptual and validation phases and then support the detailed design effort in later phases.

2.5 LIFE CYCLE COST

The life cycle cost of a system is the total cost to the Government of acquisition and ownership of that system over its full life. It includes cost of development, acquisition, operation, support, and where applicable, disposal. The intent of LCC analysis is to provide cost data for decision-making during all stages of the system acquisition process.

The techniques used to acquire LCC data will range from parametric cost estimating techniques in the early acquisition stages to engineering costing techniques as the system configuration becomes better defined. Initially, the LCC analysis will provide estimates for Government review discussions. Finally, LCC requirements will be placed upon participating contractors and will be a key factor in design and/or product evaluations, source selection, and program continuation decisions.

2.6 PERFORMANCE/SUPPORT/COST/SCHEDULE

The major considerations within this weapon system acquisition process are performance, support, cost, and schedule. All interrelate and must be continually monitored during the acquisition process.

The achievement of performance is normally well-defined because it has often been the consideration of prime importance. As a result, a very rigorous systems engineering approach has already been developed and is documented in many regulations, manuals, and standards.

Similarly, there is a very rigorous methodology for developing and monitoring schedule and the acquisition portion of cost.

Support, however, has often been of secondary consideration. The development of the support elements of a weapon system has always been a reactive process rather than a participative one relative to the development of the operational elements. Presumably, it is felt that support cannot be developed until after the operational equipment is fully defined. In an attempt to correct this problem, the integrated logistic support concept was developed. The goal was to systematically integrate the various support elements as information became available.

Cost has always been a key factor in the acquisition process with respective acquisition costs receiving a great deal of detailed consideration. Ownership costs, while acknowledged, were very rarely addressed and often totally ignored. As a result, decisions have been made with only acquisition costs in mind and have created severe ownership cost impact. Because of this fact and the recognition that ownership costs are a prime contributor to the defense budget, a continuing and ever-increasing emphasis has been placed on determination of total life cycle costs.

Although all of the various support and cost elements and their interrelationship and interdependency are now acknowledged, the tools to adequately address them are not yet available. Because support elements cannot be quantified and optimized, cost, specifically the ownership cost prediction, lacks validity during early life cycle phases.

Some very specific and valuable work has been done in addressing the more efficient definition and allocation of support elements. In particular, a significant amount of work has been done by all the services on support elements which are particularly sensitive to human resources. The Air Force Human Resources Laboratory has been a prime contributor in this effort.

2.7 HUMAN RESOURCES/SUPPORT AND COST CONSIDERATIONS

Such human resource-related support elements as manpower quantities, job skill specialties, task performance proficiency, personnel availability, training, training aids, quality of technical data, and support equipment have a very real effect on the operational capabilities of a system and outyear support costs. These elements are most often dictated by policy or else result from the equipment selection process. These elements rarely are quantified properly early in a program so that they may become a part of the design criteria or accurately contribute to LCC predictions.

Although the need is discussed in MIL-STD 1388, Integrated Logistic Support Analysis, the methodology to meet it is not established. Specific human resource technologies such as MMM, ISD, JGD, SOC, and HRDT have been developed to address portions of this problem. These will be defined in the next section.

Human resource data presently derived from these technologies is generally limited to use in the full scale development and the validation phases. CHRT will be developed to provide, in addition, the more general data required during the earlier phases. There are also significant interfaces among these techniques and procedures which suggest that their integration would be beneficial. Such an integration allows for the coordinated and more powerful application of these technologies.

It is within the integrated logistic support concept that human resource data is required to determine the ILS elements. The combined ILS element data is then available for use as an input to the life cycle cost effort. Although this data is required in all phases of acquisition, the methodology for acquiring it, especially in the earlier phases, is still unavailable. The goal of the coordinated human resource technology is to provide such a methodology derived from an integration of the five human resources technologies.

Section 3
THE HUMAN RESOURCES TECHNOLOGIES

3.1 OVERVIEW

This section covers the present application, major activities, events, and interfaces of the five human resources technologies which are defined as follows:

- Maintenance Manpower Modeling - MMM - provides a method for estimating the maintenance manpower requirements for new weapon systems and for evaluating the effect of certain system level trade-offs.
- Instructional System Development - ISD - a method which identifies a need for an instructional program, and then systematically optimizes its length, content, and means of presentation.
- Job Guide Development - JGD - a method of developing improved technical data for use by maintenance personnel. The methodology includes systematic steps identifying and analyzing tasks to develop effective procedures, and for presenting the procedures in a step-by-step manner supported by detailed illustrations.
- System Ownership Cost - SOC - a systematic method of estimating ownership costs and its associated high cost drivers.
- Human Resources in Design Trade-offs - HRDT - an approach utilizing design option-decision trees (DODT) for identifying major design decision points so that trade-off studies may be influenced through consideration of the human resource impact.

These technologies are presently in various stages of use and development. In general, they are all evolving and maturing. None has been applied across all phases of weapon system acquisition life cycle, nor has their potential been fully explored or exploited.

Upon investigation, one finds that there are specific interfaces among these technologies and definite similarities in data requirements. This section will identify these interfaces, similarities, and trade-offs between the technologies.

3.2 PRESENT APPLICATION

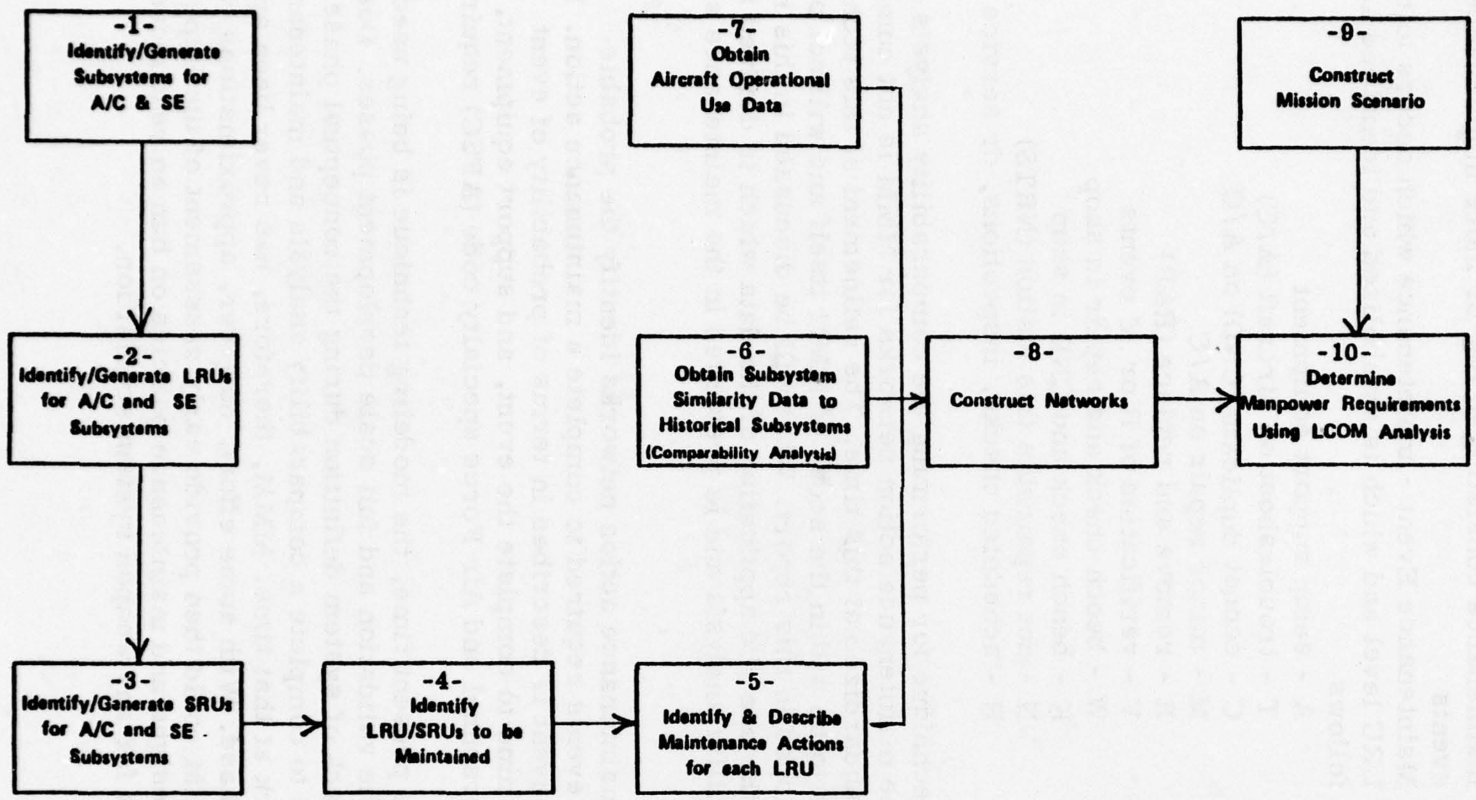
The following paragraphs describe the human resource technologies as presently perceived and discuss their status and application. It is important to note that although the text relates the technologies to various phases of weapon system acquisition, the relationship of the associated flow diagrams to the acquisition time line is not shown so that the interfaces and similarities may be developed without regard to time. The premise is that if the technologies can be integrated, they can then be applied continuously and in concert. Operating from a common data base they can then provide the specific information or products required. The flow diagrams identify the major activities and events of each technology. They consist of all those traditionally accomplished with some minor modifications for continuity.

Maintenance Manpower Modeling (MMM)

MMM provides a method for estimating the maintenance manpower requirements for new weapon systems and for evaluating the effects of certain system-level tradeoffs. A general flow diagram for MMM is shown in Figure 3-1. The evolution and use of these procedures are described in a series of five reports published by AFHRL entitled, "Simulating Maintenance Manning for New Weapon Systems," AFHRL-TR-74-97 (I-V). (See reference list)

Maintenance manpower modeling has been successfully applied several times on different aircraft systems. Data based on Air Force experience with systems comparable to that being simulated were adjusted to approximate the characteristics of the simulated system. This data, coupled with a definitive operations scenario and maintenance concept, allow one to develop a maintenance action network which reflects the nature of the simulated system. This network coupled with a mission scenario is then simulated using the Logistic Composite Model (LCOM). The output generated by the simulation is processed through ancillary programs to provide a prediction of the maintenance manpower required to support the system.

The key to the successful application of MMM in itself is the comparability analysis and the development of the maintenance action networks. The comparability analysis equates planned design to comparable hardware for which failure data is available. The result is estimated failure data on the planned design based on comparability. The maintenance action networks are in turn composed of discrete maintenance events. The terms maintenance action and maintenance event as used in MMM are defined as follows:



MAINTENANCE MANPOWER MODELING FLOW DIAGRAM

Figure 3-1

- Maintenance Action - scheduled or unscheduled maintenance consisting of one or more maintenance events
- Maintenance Event - maintenance which occurs to the LRU level and which is symbolized and identified as follows

  A - setup support equipment
  T - troubleshoot on aircraft (A/C)
  C - cannot duplicate (CND) on A/C
  M - minor repair on A/C
  R - remove and replace (R&R)
  V - verification of R or M events
  W - bench check and repair in shop
  K - bench check and CND in shop
  N - not repairable this station (NRTS)
  H - scheduled checks, inspections, or service

The technique for performing the comparability analysis and developing the maintenance action networks for MMM is not completely defined or standardized at this time. The refinement of this technique is considered to be within the scope of MMM itself and will not be further developed in this report. What will be discussed in this report, however, is the use and application of the data which is derived from the comparability analysis and is presented in the maintenance action networks.

The maintenance action networks identify the probable maintenance events required to complete a maintenance action. Each maintenance event is described in terms of probability of event occurrence, time to complete the event, and support equipment, number of personnel and Air Force specialty code (AFSC) required.

At the present time, the modeling technique is being used during both the validation and full scale development phases. Due to the general lack of system definition during the conceptual phase, it is very difficult to complete a comparability analysis and maintenance action network at that time. MMM, therefore, has never been applied during this phase. With some effort, however, approximations could be made. MMM could then provide early assessment of the impact of alternative designs and maintenance policies on human resources requirements for any weapon system acquisition.

Another aspect of the MMM technology is the R&M model developed by Dynamics Research Corporation (DRC) as part of the Digital Avionics Information System (DAIS) Life Cycle Cost Modeling System Study (Czuchry, et al, 1978). This technique formats the maintenance event data in matrices and computes average demand on the maintenance system for an unconstrained maintenance environment. No attempt is made to account for peak loads, saturations, queues, or other non-linear constraints. Average demand on the maintenance system over a period of flying hours is sufficient for assessing support resources during the conceptual phase and to screen alternatives for viability prior to application of LCOM during the validation phase. Although this R&M model is a less accurate method for predicting maintenance manpower requirements than the LCOM simulation, it can be reiterated more quickly and economically than LCOM. In addition to maintenance manpower requirements, this technique quantifies reliability ($\overline{R}$) and maintainability ($\overline{M}$). All data are expressed in terms that are useful to system designers, maintainers, operators, and logisticians. It should be noted, however, that the R&M model is also directly dependent on having the comparability analysis and maintenance action network description available.

Instructional System Development (ISD)

The application of instructional system development principles and processes for the development and accomplishment of education and training programs throughout the United States Air Force is directed by AFM 50-2. Guidance for the application of ISD is provided in AFP 50-58.

Specifically, Air Force policy regarding ISD as stated in AFM 50-2 is as follows:

- Apply ISD to produce all new instructional systems.
- Subjectively apply ISD to existing instructional systems when economically feasible.
- Train-to-requirements. Design to contain only the appropriate education/training instructional systems.
- Develop quality training at the least cost by applying ISD.

Inherent in ISD is a decision process which can terminate application of ISD at any one of several points. After determination of what the job involves, the instructional system designer must determine if instruction is appropriate. If not, application of the process is terminated. If instruction is the solution, the designer must determine what instruction is needed to enable the target population to meet the job requirements and how best to meet this need.

Although the tendency is to think immediately in terms of formal courses, the decision process requires consideration of less expensive alternatives (reassigning qualified personnel, use of performance aids, etc.). If reassigning qualified personnel resolves the problem, and they are available, that is as far as the ISD process is pursued. If a formal course is determined to be appropriate, there are still several options and they are: using an existing course, modifying an existing course, or developing a new course. The remainder of the ISD process then involves designing instruction to meet the identified needs in a cost-effective manner and evaluating its applicability.

The questions to be answered are:

- Is instruction appropriate?
- What instruction is needed?
- What type of course is needed?
- What is the course content to be?

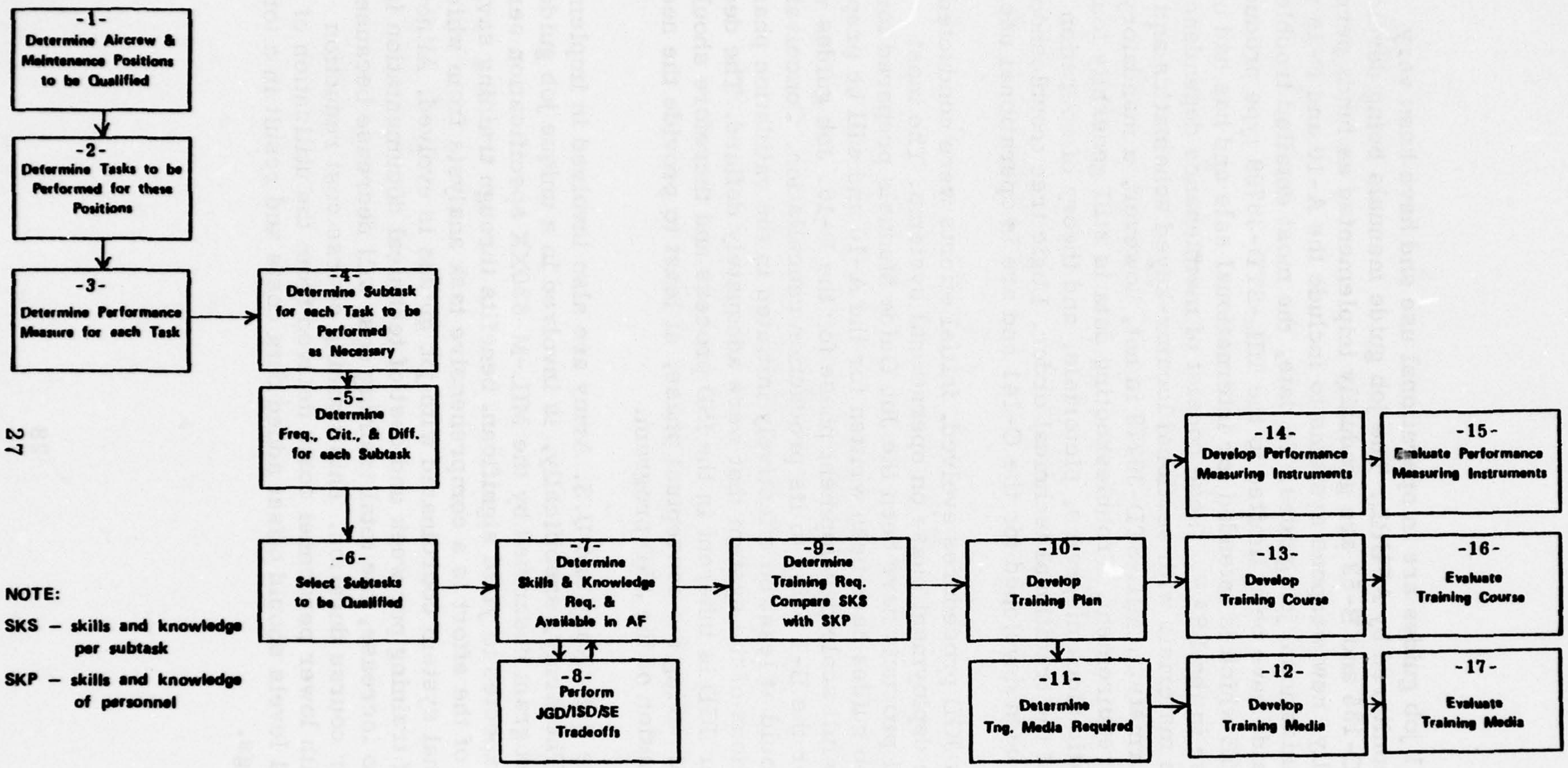
The answers to these questions are obtained through a task analysis.

A flow diagram for ISD is shown in Figure 3-2.

In the broadest sense, the ISD process might be considered as being employed during the conceptual phase to evolve a training concept. It is not, however, until the validation phase that there is any significant activity which results in a training plan. The ISD processes do not reach their maximum levels of activity until well into the full scale development phase when the operational and maintenance tasks can be defined in terms of specific equipment and specific functions. Verification must wait until the production phase when the validity of the task analysis can be truly evaluated in the actual related environment by trained personnel of the requisite skill types and skill levels. This usually results in changes to the training courses and may even lead to a delay in providing trained operator and maintenance personnel.

Job Guide Development (JGD)

The Air Force has made significant progress in implementing JGD procedures through its Technical Order Improvement Program. Under this program, guides for non-troubleshooting tasks (Job Guide Manuals) have been prepared for organizational level maintenance of three existing major aircraft systems: the KC-135, B-52, and C-141.



INSTRUCTIONAL SYSTEM DEVELOPMENT FLOW DIAGRAM

Figure 3-2

The C-141 job guides are in operational use and have been very closely monitored by AFHRL. The job guide manuals being developed for the KC-135 and B-52 are gradually implemented as funds permit. Additionally, new weapons systems to include the A-10 and F-16 will have organizational job guides. To date, the most detailed troubleshooting aids have been limited to the MIL-STD-38799 type products on the F-5E which is intended for international sale and has had only limited use in the USAF. These consist of maintenance dependency chart type materials with sectional locator-keyed schematics and keyed information. MIL-STD-39779 is not, however, a mandatory tech data requirement. Troubleshooting data is still generally found in schematic block diagrams, pictorials, and theory of operation sections of the traditional technical order. Logic tree troubleshooting aids have been developed for the C-141 and are in operational use.

As JGD procedures evolved, initial efforts were conducted during the deployment phase on operational systems. The most successful products have been the Job Guide Manuals prepared for the C-141. Job guides have been written for the A-10 and will be prepared during the full scale development phase for the F-16. Job guides were planned for the B-1 prior to its production cancellation. Conceivably, the JGD could at least be effectively initiated in the validation phase on those portions of the system that were adequately defined. The decision to consider JGD is inherent in the ISD process and therefore should be considered during the conceptual phase, at least to provide the needed cost estimation of the JGD program.

The U.S. Navy and U.S. Army are also involved in implementing JGD. The Army, specifically, is involved in a unique job guide/ training program described by the MIL-M-630XX specification series which is expected to yield significant benefits through training savings. The basis of the effort is a comprehensive task analysis from which an instructional system coordinated with job guides is evolved. Although the cost of training per week and cost of technical documentation is expected to increase, the total training cost will decrease because of the shorter course duration. This training course cost reduction coupled with lower personnel costs derived from the utilization of lower skill levels should offset added data costs and result in a total cost savings.

Job guides promise improved maintenance and allow tasks to be accomplished by lesser skilled personnel than required if traditional technical orders are used. There are, however, several key steps to be considered in developing good job guides. They are:

- Conduct a task analysis
- Establish appropriate level of detail in data
- Adequately identify user-population
- Provide equipment for validation
- Conduct a 100 percent hands-on verification of JGD procedures by personnel of the planned skill level.

A flow diagram of the JGD process is shown in Figure 3-3.

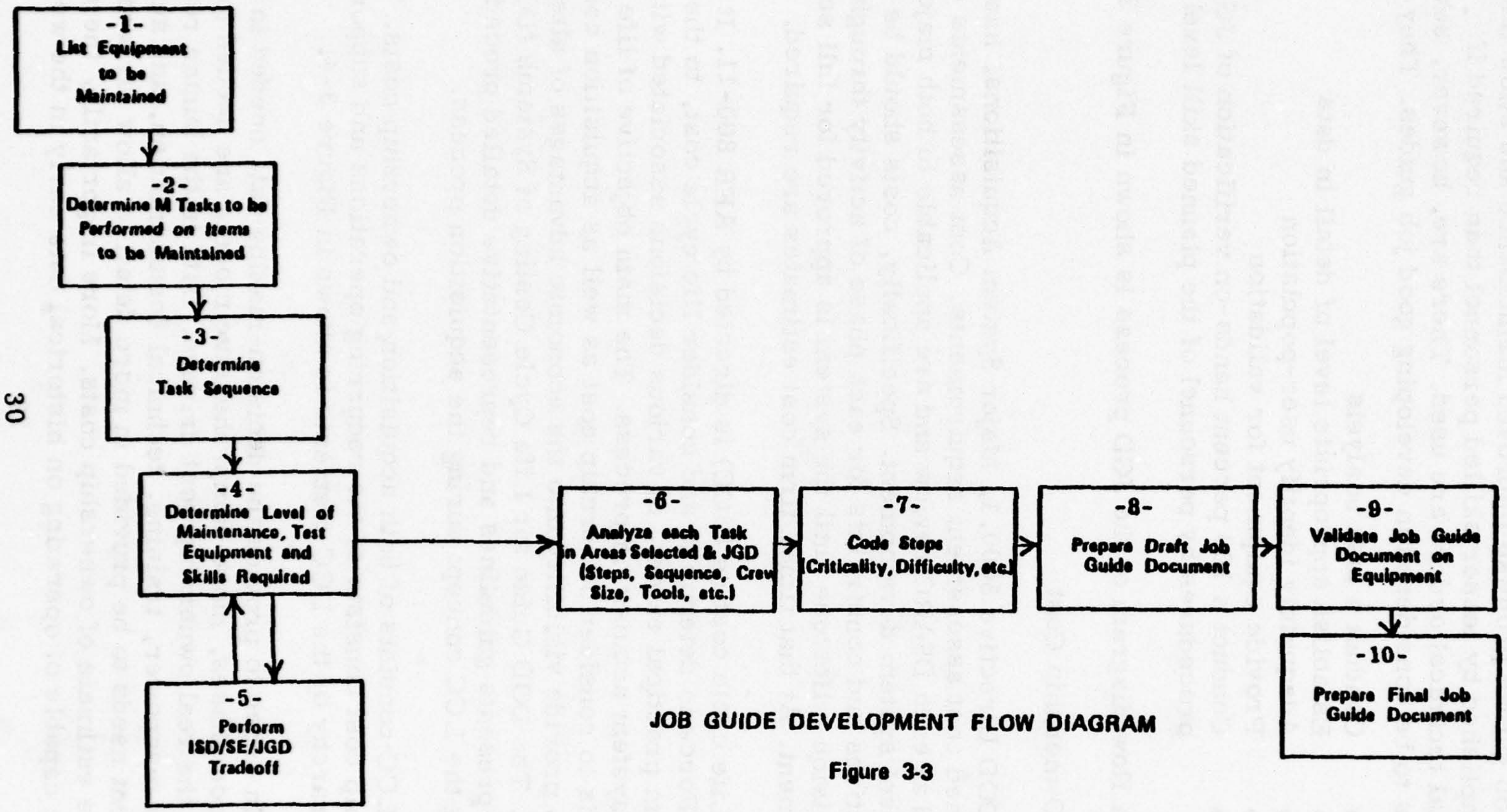
System Ownership Cost

DOD Directive 5000.1, Major System Acquisitions, has established cost assessment requirements. Cost assessments are required at each DSARC review and are applicable to both major and lower level system development. Specifically, costs should be stated as objectives and constraints for each phase of activity through the next decision milestone until the system is approved for full scale development. At that time, firm cost estimates are required.

Life cycle costing (LCC) is directed by AFR 800-11. It directs the Air Force to determine and consider life cycle cost, to the maximum practical extent, in various decisions associated with the weapon system acquisition process. The main objective of life cycle costing is to consider ownership cost as well as acquisition costs in order to provide visibility into the economic advantages of alternative designs. The DOD Guide for Life Cycle Costing of Systems (DOD Guide LCC-3) presents guidelines and representative detailed procedures for applying the LCC concept during the acquisition process.

LCC consists of both acquisition and ownership costs. The ownership cost consists of the recurring operations and support costs. The hierarchy of the LCC elements is shown in Figure 3-4.

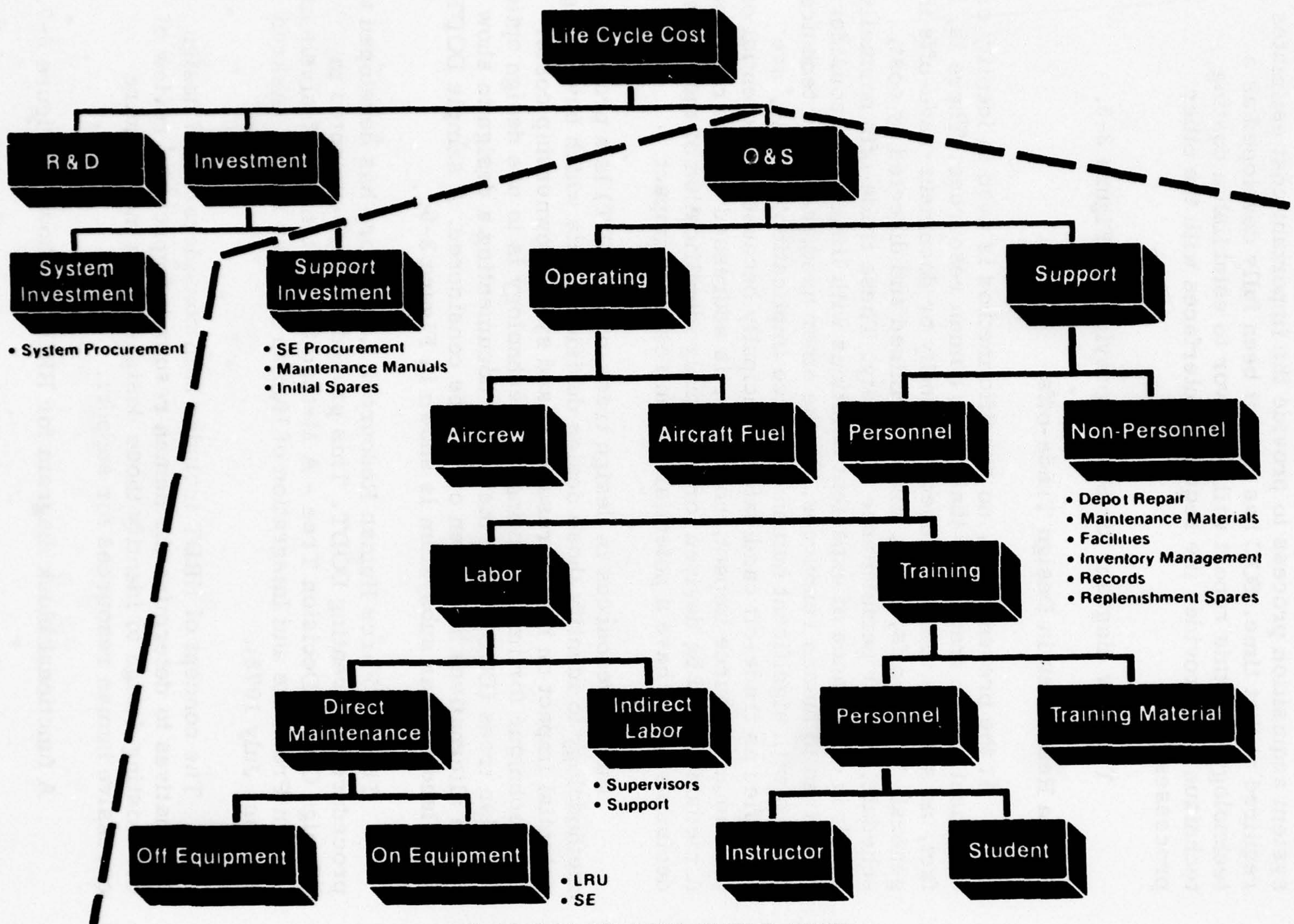
In order to provide the decision-making data needed in all acquisition phases, more comprehensive models are needed to identify the real ownership cost drivers. Data in the human resource areas of manpower, training, technical documentation, and support equipment needs to be provided in more detail to allow for a more effective estimate of ownership costs. More importantly, the model must be capable of operating on historical data early in the weapon



JOB GUIDE DEVELOPMENT FLOW DIAGRAM

Figure 3-3

NOTE: This sequence presents a generalized flow for JGD. The details of the specific steps may be found in AFHRL-TR-73-43. The approach detailed there in is the basis for the CHRT integrated task analysis performed during full scale development.



HIERARCHY OF LIFE CYCLE COST

Figure 3-4

system acquisition process to provide the important cost estimates required at that time. SOC has not yet been fully developed as a technology, but this report will endeavor to establish a costing technique that provides the required interfaces with the other processes.

The flow diagram for SOC is provided in Figure 3-5.

Human Resources in Design Trade-offs

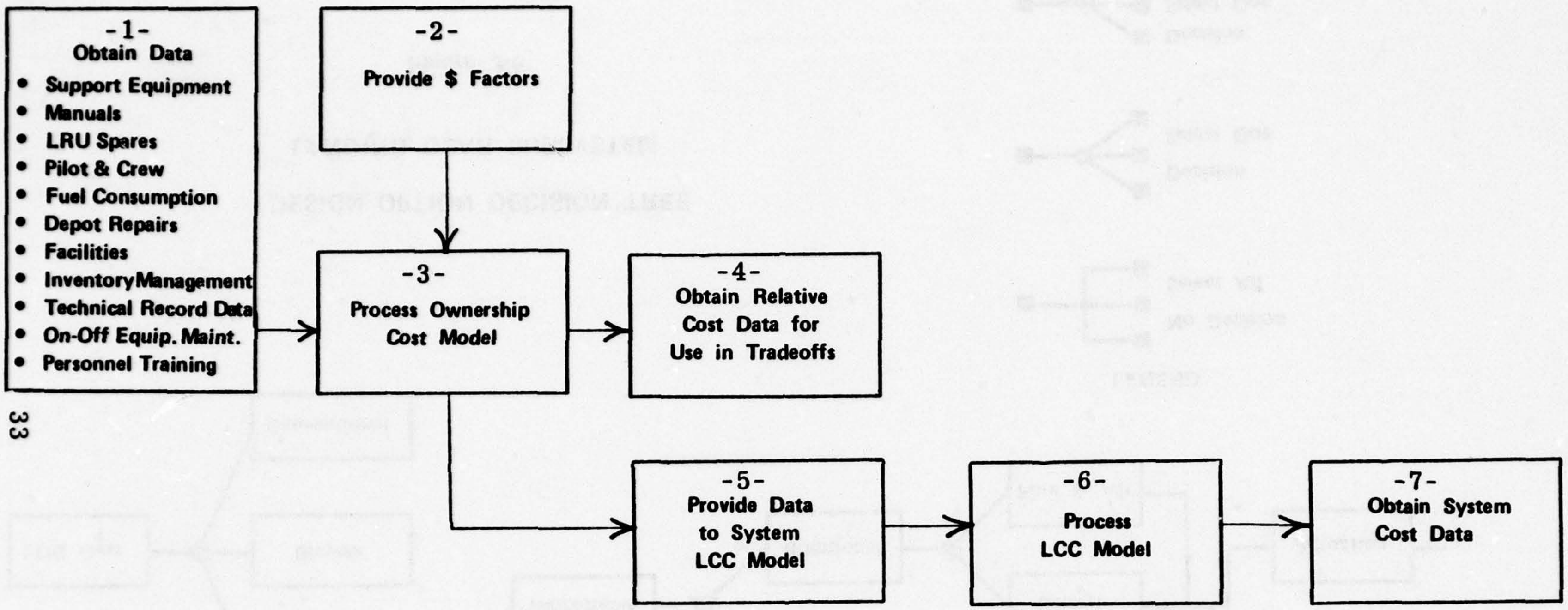
At the present time, no specific method is used to identify or document design trade-offs that affect human resources. There is, in fact, no specific technique used to identify or document trade-offs in general. Trade-offs, often, are determined and directed by cost, schedule, and/or performance necessity. These trade-offs normally result in acceptance of expedient solutions with little or no consideration given to human resources. On the other hand, adequate technical designs with significant human resource implication, rarely, are identified as trade-off candidates principally because the potential of the human resource impact, normally, is addressed only in retrospect. A method should be devised for the timely identification of those design decisions which have a potential human resource impact.

Human resources in design trade-offs (HRDT) is a proposed methodology to identify those design decision points which have a high potential impact on human resources and system ownership costs. One technique for implementing this technology is to use design option decision trees (DODT) as a method of documenting a design to show where alternatives have been or will be considered. A sample DODT for a landing gear subsystem is shown in Figure 3-6.

The Air Force Human Resources Laboratory has developed a procedure for creating DODT. This procedure is documented in "Design Option Decision Tree - A Method for Systematic Analysis of Design Problems and Integration of Human Factors Data," (Askren and Korkan, July 1975).

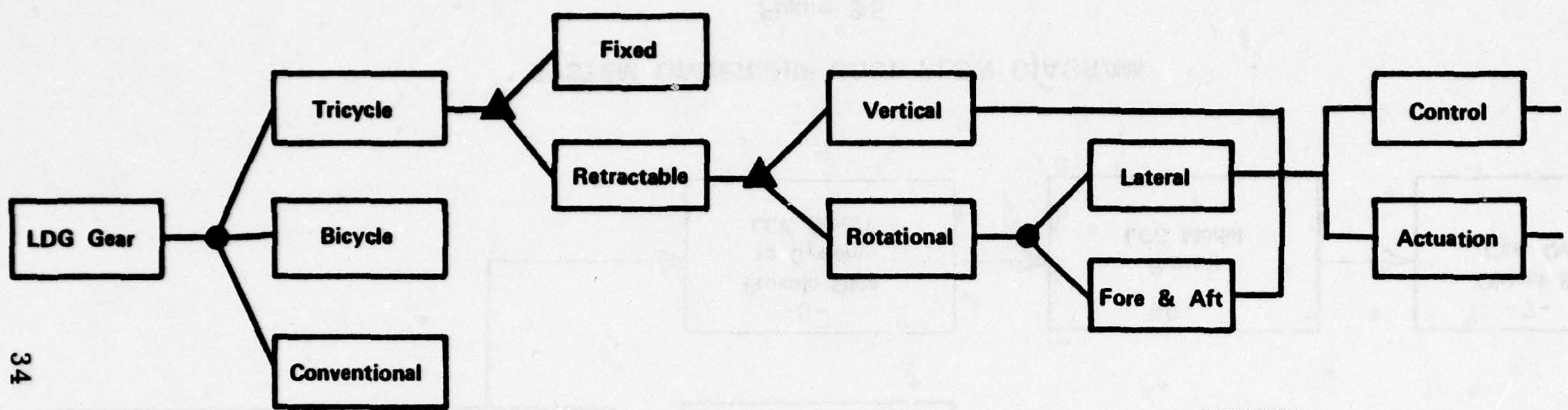
The concept of HRDT includes both consideration of design alternatives to determine the human resource impact and review of the existing design to identify those designs which may require excessive human resources for support.

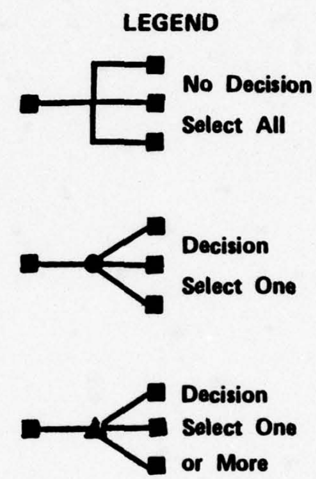
A functional block diagram for HRDT is shown in Figure 3-7.



SYSTEM OWNERSHIP COST FLOW DIAGRAM

Figure 3-5

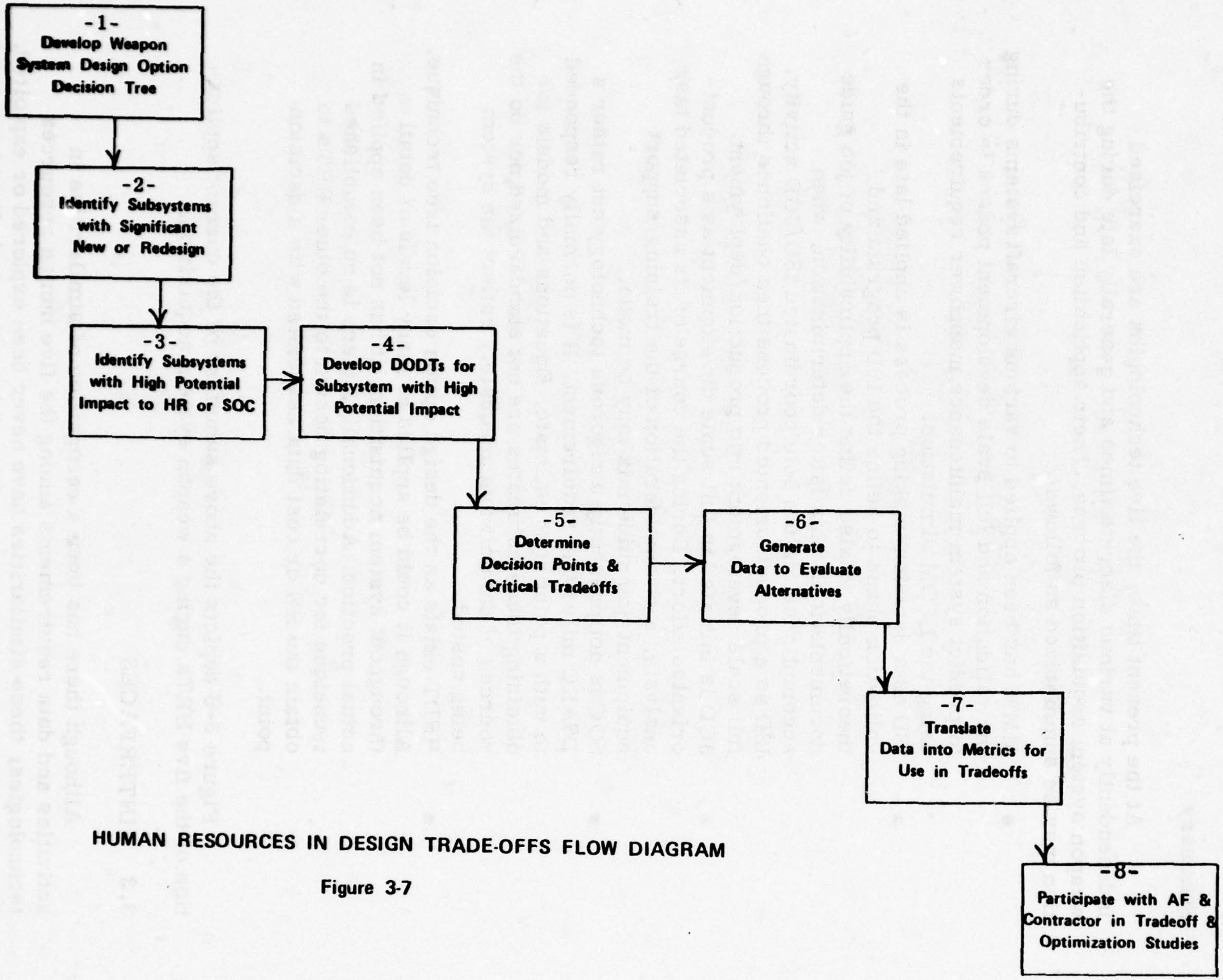




DESIGN OPTION DECISION TREE

LANDING GEAR SUBSYSTEM

Figure 3-6



HUMAN RESOURCES IN DESIGN TRADE-OFFS FLOW DIAGRAM

Figure 3-7

Summary

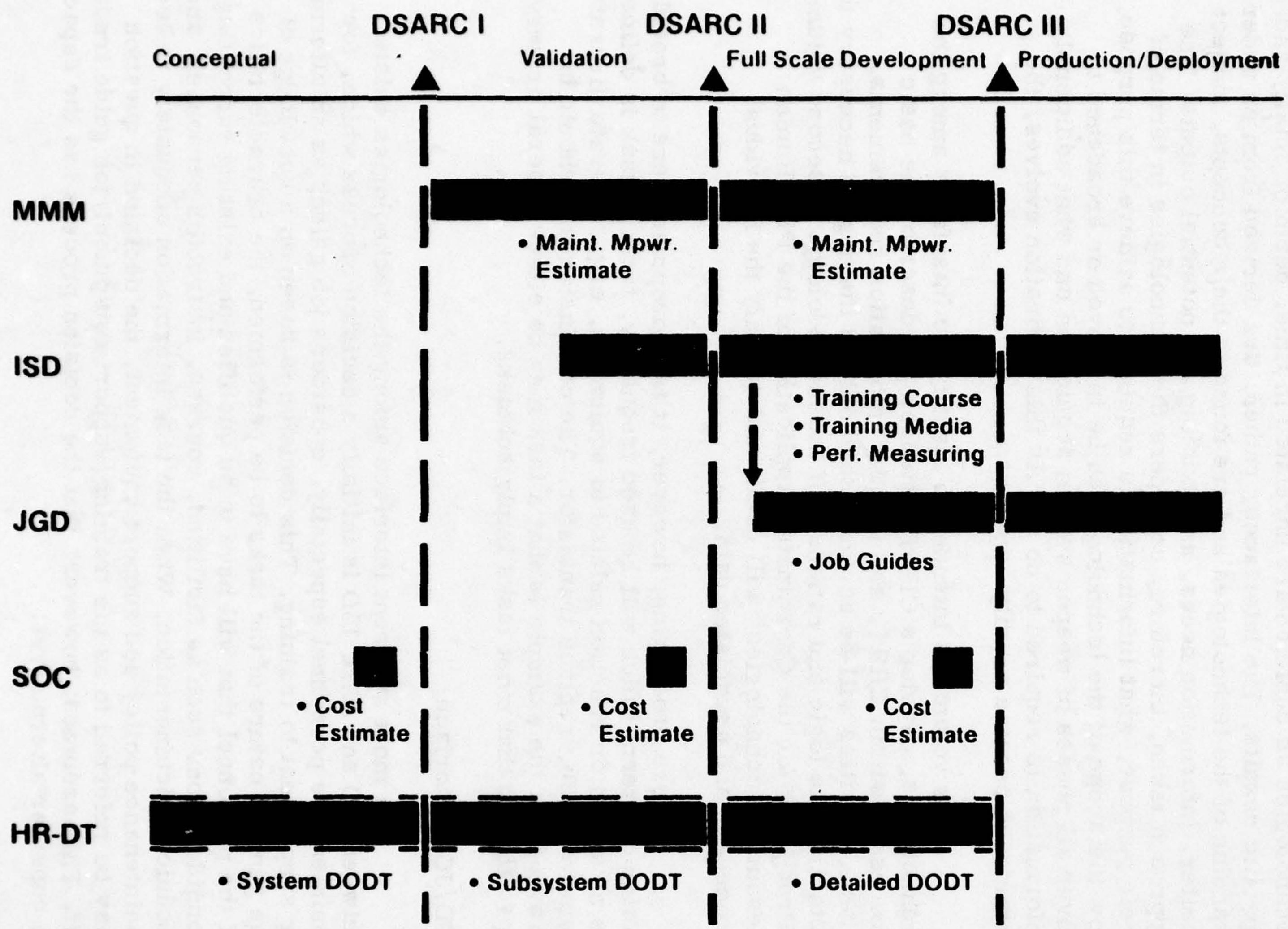
At the present time, the five technologies are exercised independently at various discrete times and generally late during the weapon system acquisition process. Their application and contribution may be summarized as follows:

- MMM has been applied to various aircraft systems during the validation and full scale development phases in order to predict system maintenance manpower requirements using the LCOM simulation.
- ISD as a decision-making process is applied late in the validation phase to define the ISD program and theoretically to also define the applicability of job guide documentation. This latter determination, when accomplished, is the sole coordinated ISD/JGD activity. ISD as a product-oriented process then continues through full scale development into production/deployment.
- JGD is initiated in full scale development as a product-oriented effort. During the course of its associated task analysis, a reconsideration of the training/support equipment/job guide mix may be made.
- SOC is not presently a rigorous technology but rather a DSARC milestone requirement. It is normally responded to with a point cost estimate. Equations and models for obtaining these estimates are not standardized nor do the sources of data always adequately reflect the system being costed.
- HRDT exists as the design option decision tree technique. Although it could be applied at many levels of detail throughout system acquisition, it has not been applied in actual practice. Additionally, there is no established technique for correlating design to the other HRTs to obtain the HR or cost data associated with a decision point.

Figure 3-8 depicts the above summary of the current application of the five HRTs during a weapon system acquisition.

3.3 INTERFACES

Although there has been a recognition of similarities in activities and data requirements among the five human resources technologies, these similarities have never been explored or exploited. These similarities or interfaces will now be addressed. It is impossible



PRESENT HUMAN RESOURCES TECHNOLOGY APPLICATION

Figure 3-8

to directly present them on the preceding flow diagrams because the technologies as depicted are unrelated in time, depth of detail, and specific results. The interfaces, rather, are derived from an understanding of the technologies and are found in their concepts, subject matter, information needs, and existing and potential outputs. The approach taken, therefore, considers the technologies in terms of their purpose, what information is required to achieve this purpose, how the scope of the technology can be improved or broadened to cover all phases of weapon system acquisition and what additional information is required to do so. As this derivation evolves, the interfaces become readily apparent.

This volume is intended to identify the interfaces among the technologies, develop a CHRT methodology, describe the basic processes within CHRT, and identify information requirements. These activities will be accomplished only to the degree necessary to establish the logic and rationale of the methodology. A second volume "Processes for the Coordinated Application of the Five Human Resource Technologies" will detail and quantify the individual processes and associated data.

Before proceeding, however, it is appropriate here to broadly define one term which will be used frequently, task. A task is defined as an action or reaction related to equipment, e.g., operate aircraft, remove radio, replace transistor. The conclusion that should be drawn from the example is that a task may be either general or very specific and that most tasks imply subtasks.

ISD/JGD Interface

The most apparent interface among the technologies exists between ISD and JGD. ISD is initially a decision process which, for maintenance personnel especially, considers job guides as an alternate or supplement to training. This decision is based on a knowledge of the general nature of the tasks to be performed, the characteristics of the personnel that will have to be qualified and existing supporting considerations such as facilities, courses, instructor personnel, and technical documentation. When the task information adequately reflects maintenance policy and support equipment, the decision in question may be referred to as the training/support equipment/job guide trade-off. This assumes, however, that the decision process has the capacity to consider alternatives.

Additionally the end result of both ISD and JGD are the very specific products: training and job guides. Associated with each of these technologies is a detailed and nearly identical task analysis from which the products are evolved.

The interface between ISD and JGD, therefore, is a common dependency on task information and the common goal of assuring adequate human performance. General task information is needed to determine the basic requirement for training and job guides for any specific weapon system design. Knowledge of this basic requirement, in turn, is required to estimate system ownership costs and describe the training and tech data programs. Detailed task information is required to actually produce the products. This latter effort could be accomplished any time such detailed data is available; however, this effort is not performed until full scale development when the weapon system specification is fully approved.

As a result of the interfaces described above the following improvement and/or broadening of the ISD/JGD interface is set forth.

- Initiate the ISD/JGD decision process as an analytical tool during the conceptual phase to define the ISD/JGD requirement. This human resource requirement will then be reflected in the SOC estimate at DSARC I and in the training and tech data concepts.
- Continue the ISD/JGD decision process as an analytical tool during the validation phase to refine the ISD/JGD requirement. This human resource requirement will then be reflected in the SOC estimate at DSARC II and in the training and tech data plans.
- Initiate a single integrated task analysis (ITA) during full scale development that addresses the training/support equipment/job guide trade-off, and that is applicable to both training and job guide development.

The following additional information is required:

- General task information, personnel characteristics, and supporting considerations will be required during all phases of acquisition. Comparable historical data will be used initially and upgraded to on-equipment data on an as-available basis. During full scale development, on-equipment data will be used and derived from the ITA.
- General and detailed task information will be derived from an ITA during full scale development for maintenance personnel. A more traditional type of task analysis related directly to ISD will be accomplished for the operator.

All data required to effect and describe these activities once acquired will be stored as part of a consolidated base.

MMM/ISD/JGD Interface

Implementation of MMM is based on general task information, which is, specifically, equipment-related maintenance event data. This data is obtained as part of the existing MMM technology through a comparability analysis and the development of maintenance action networks. This data is used in the LCOM simulation to predict maintenance manpower requirements. Utilizing the R&M model, maintenance event data in matrix format may be evaluated to predict $\overline{R}$, $\overline{M}$, and maintenance manpower requirements. Although, the latter provides estimates which are less accurate than those derived through LCOM. The advantage in it is the reduced computer time required to perform a simple mathematical operation rather than an operational simulation. This simpler technique encourages iterations for evaluation of alternatives.

Using either technique, LCOM or the R&M model, the alternative design, maintenance, and support approaches may be compared in terms of maintenance manpower requirements as long as the task information is updated to reflect the alternatives. The $\overline{R}$ and $\overline{M}$ assessments can currently be determined only using the R&M model.

The human resource requirements, $\overline{R}$, $\overline{M}$, and maintenance manpower are necessary information to evaluate any specific weapon system design and are also necessary for estimating system ownership costs. Most importantly, the MMM/ISD/JGD interface is called for because of the fact that the general task data used in MMM can partially provide the general task information needed for the ISD/JGD process in the conceptual and validation phases.

As a result of these desirable MMM/ISD/JGD interfaces, the following improvement and broadening are added to MMM:

- Initiate MMM in the conceptual phase to the extent of developing the general task data from the comparability analysis and the maintenance action networks. Investigate $\overline{R}$, $\overline{M}$, and maintenance manpower requirements using the R&M model. The results will be reflected in the SOC estimate for DSARC I. The general task data input and the maintenance manpower requirements output will both be input data to the ISD/JGD decision process.

- Update MMM in the validation phase through a review of the comparability analysis and maintenance action networks. Investigate $\overline{R}$, $\overline{M}$ and maintenance manpower requirements of significant interest. The results will be reflected in the SOC estimate for DSARC II. The general task data input and the maintenance manpower requirements output will both be input data to the ISD/JGD decision process.
- Update MMM in the full scale development phase by replacing the general task data with that derived from the initial steps of the ITA. Use LCOM to validate maintenance manpower requirements. Obtain $\overline{R}$ and $\overline{M}$ for use with SOC through the R&M model. Feedback maintenance manpower requirements to ISD/JGD for final mix decision.

The following additional information is required

- Historical comparability and expected configuration estimates will be required early in the conceptual phase to support the MMM comparability analysis and development of maintenance action networks which provide general task information.
- On equipment data or estimates will be required as early as possible in the validation phase to update the MMM comparability analysis and development of maintenance action networks which provide general task information.
- General task information will be provided to the MMM process through the initial steps of the ITA in the full scale development phase.

Although this integrated task analysis in full scale development may seem to be a very obvious solution to resolving the problem of three redundant task analyses, a single task analysis is not currently being accomplished for a number of reasons. The most significant are (a) ISD and JGD are not a coordinated effort (b) ISD and JGD are accomplished by separate agencies. As a result, it is expedient for the agencies involved to conduct their own task analyses. The responsibilities of these agencies generally lie in the following areas:

Agency	Area of Responsibility
AFSC (SPO)	Manage MMM, ISD, and JGD
AFSC (ASD/EN)	Perform MMM
ATC	Perform ISD
Contractor	Perform JGD
Using Command	Monitor MMM, ISD, and JGD
AFLC	Monitor JGD

Again all data required to perform these activities once acquired will be maintained in the consolidated data base.

MMM/ISD/JGD/SOC Interface

The MMM/ISD/JGD human resource requirements (i.e., $\overline{R}$, $\overline{M}$, maintenance manpower, training, and job guides) must be evaluated and one of the criteria must be cost. Consequently, the SOC technology uses an accounting type of model to apply factors to MMM/ISD/JGD parameters in order to estimate cost of ownership. This downstream cost can then be weighed against the acquisition cost to determine if front-end investment should be increased or decreased.

A very significant additional set of system-dependent HR requirements must be considered. These are operational manpower and the necessary ISD to support this manpower requirement. Because of the quality of personnel and type of duty, qualification of operator personnel is considered a predominately ISD process.

Additional standard data required for the SOC model such as personnel pay rates, flying hours per year, number of aircraft, cost of maintaining a spare part, etc., will be obtained directly from the appropriate source and updated as necessary.

The specific SOC model and associated data will be stored in the consolidated data base. The model will maximize the ability to cost the human resources requirements discussed. Cost plus the human resources requirements may then be jointly used to evaluate and describe the impact of any alternative.

MMM/ISD/JGD/SOC/HRDT Interface

Having used SOC to cost the MMM/ISD/JGD/operational related human resources requirement, the possibility of developing comparative data for viable design, maintenance, operations, and support alternatives should be considered. This would then allow human resources and their associated cost to become a real consideration in influencing the selection of an acceptable alternative. Additionally, this should be possible very early in the weapon system acquisition cycle because it is here that the major decisions which affect system ownership cost are made. The fifth technology, HRDT, satisfies this need. It is initially applied on a system level during the conceptual phase to participate in system level decisions and then to

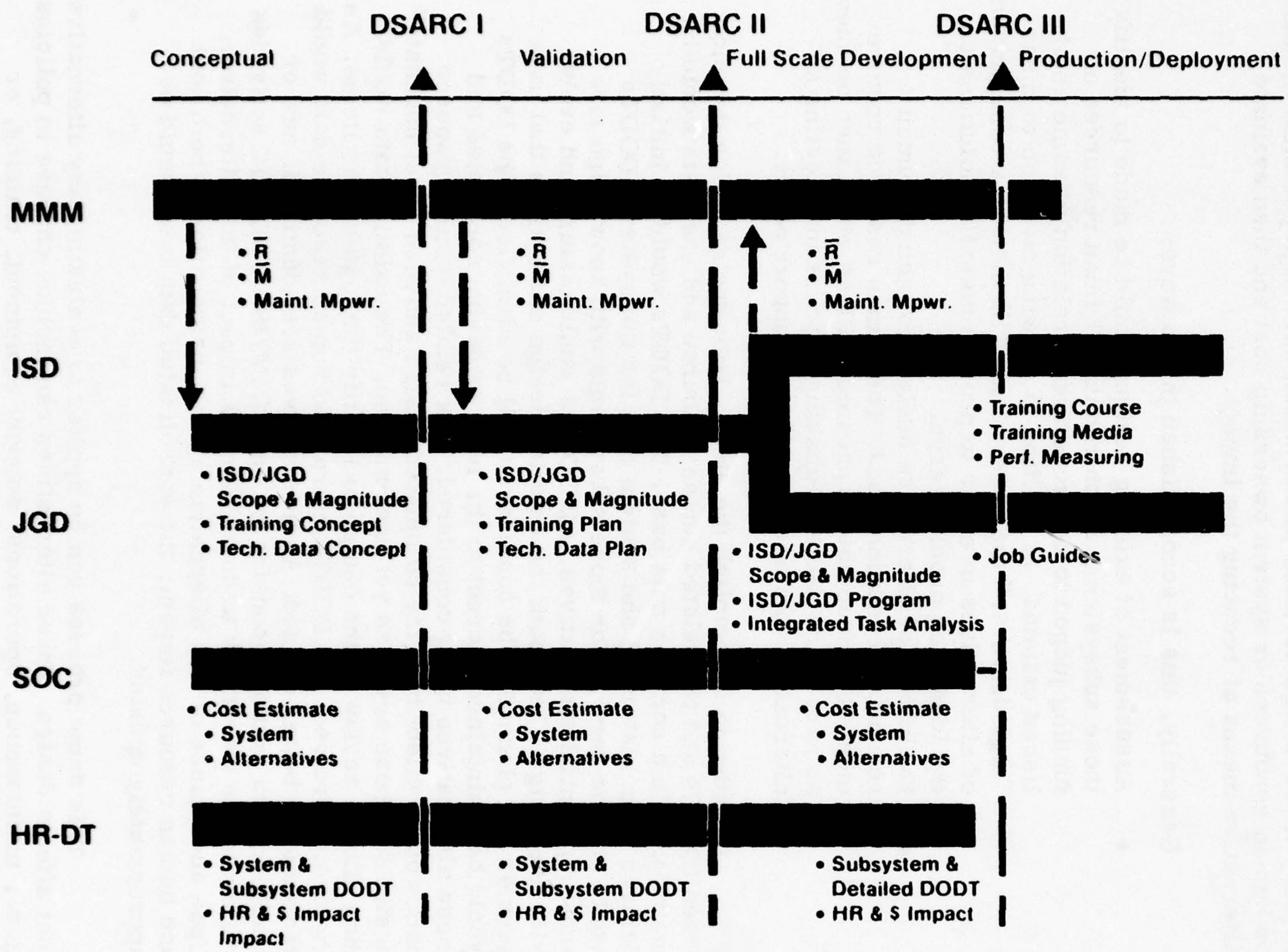
lower levels, as necessary, The HRDT provides a capability to first identify those design decision points which have high potential impact on human resources or system ownership cost and then evaluate alternative means of reducing the impact.

Generally, this is accomplished in two ways:

- Assessment of existing designs would be made to identify those subsystems which required human resources or funding judged to be excessive in relation to some established criteria. In addition to drawing attention to these "high drivers," the assessment will include a comparison of alternatives in order to provide potential solutions to the identified problem area.
- Evaluation of alternative designs to include human resources considerations. The human resource requirements and associated cost implications would then be used as part of the decision-making process in selecting an alternative equipment design or support policy.

[redacted] the [redacted] option decision trees (DODT) and the related human resource and cost data would be maintained in a common data base. The DODTs would be initially derived from historical and system data for the system. DODTs would also be derived for those subsystems with known high risk and/or potential alternatives. All DODTs would mature and evolve with the design. Thus both the existing design and options that have been or are planned to be considered will be identified. The DODTs would be maintained current to the level of design completed and those alternatives being considered. The related human resource data would reflect both the completed design and also "best estimate" design for those areas as yet uncompleted. The existing data would then allow a review of the design to identify the high driver items. As the design evolved, the DODT and related human resource data would grow and be better defined. As alternatives are identified, new or modified data would be considered and MMM/ISD/JGD/SOC activities reiterated as necessary to determine the impact of that alternative. Upon acceptance of that alternative after consideration of both cost and human resource impact, the consolidated data base would be appropriately updated.

This same process can be applied to evaluating any alternative that affects design. These alternatives can include changes in policies (i.e., maintenance, operations, support equipment, training, or manuals).



PROPOSED HUMAN RESOURCES TECHNOLOGY APPLICATION

Figure 3-9

Summary of Interfaces

The previous paragraphs have identified the interfaces among the human resource technologies. The key activities that were described are:

- The development of a consolidated data base. It should be noted that many of the preliminary activities in each technology contribute to this development.
- The integrated analysis of specific data to identify human resource requirements.
- The use of an integrated task analysis to determine the content of the ISD and JGD products.
- The evaluation of the human resource and cost impact of design, maintenance, and support alternatives.
- The identification of alternative designs and a means of iterating the entire integrated process.
- The update of the data base with new, modified, or impact data.

This proposed human resource technology application is depicted in Figure 3-9. Generalized functional flow diagrams depicting the above activities are provided in Figures 3-10 and 3-11 which cover specific acquisition phases. These interfaces will be developed in the next section as CHRT.

Data Requirements

It has been stated that the technologies have similar data requirements. A matrix of the general data requirements for the five technologies is shown in Table 3-1. The technology with which a currently used data item is associated is indicated by an "X" in the table. This table includes both existing and new data items that will be required to support the coordinated application of the five human resource technologies.

Teachnology Trade-offs

The similarities in data requirements point directly toward trade-offs among the technologies. For example, a decision regarding the use of automatic in lieu of standard test equipment can effect all the technologies either directly or indirectly. A decision in favor of automation causes changes in the MMM maintenance activity times, the ISD and JGD content and format, and the manpower requirements.

Some parameters of SOC will also change directly due to the investment in automation and indirectly as a reflection of the MMM/ISD/JGD parameters. The DODT will change indirectly as a result of the need to reflect any resulting hardware change.

Potential trade-offs among the technologies can be affected by a change in any one data item. In fact, Table 3-1 could be used to assure that all indirectly related data items are considered whenever any one data item is directly changed for the purpose of evaluating an alternative.

Conclusion

This section has shown that there are definite interfaces and similar data requirements among the technologies. The potential for consideration of trade-offs among them has been identified.

The interfaces, data similarities, and trade-offs have been developed and related to the weapon system acquisition time-line. Section 4 will describe the CHRT as integrated from the elements of the five technologies and its application in each of the weapon system acquisition life cycle phases. The application of CHRT will exploit the interfaces, similarities, and trade-offs discussed.

HUMAN RESOURCE TECHNOLOGY DATA

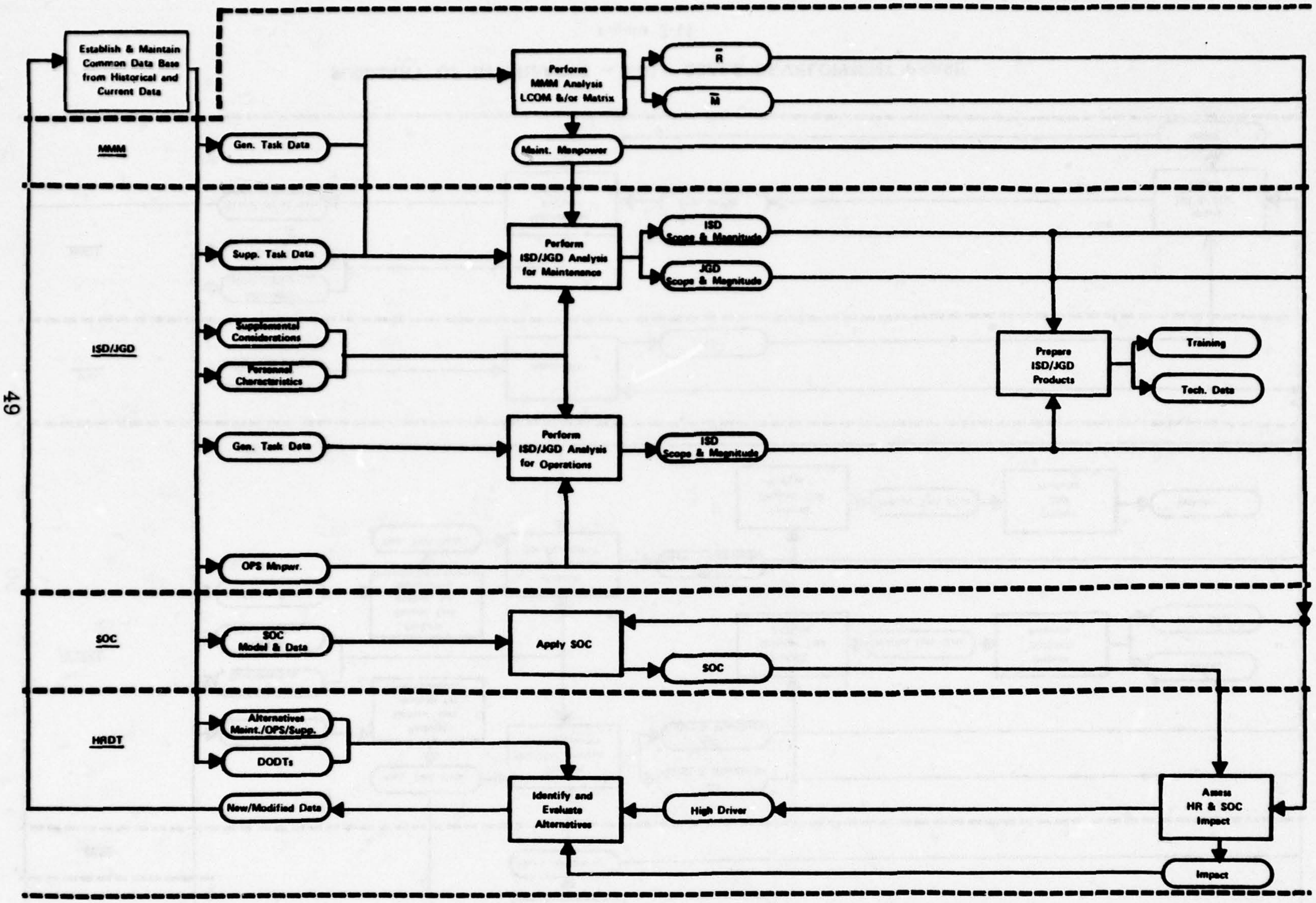
DATA ITEM	HRDTT	MMMT	JGDT	ISDT	SOCT
1. Viable Design Alternatives	X				
2. Other Alternatives	X				
a. Training	X		X	X	
b. Manuals	X		X	X	X
c. SE	X	X	X	X	X
d. Maintenance	X	X	X	X	X
e. Operations	X			X	X
3. Support Goals					
a. Reliability		X			
b. MMH/FH		X	X	X	X
c. Availability		X			
d. UDL		X	X	X	X
e. Spares		X	X	X	X
4. Unit Cost Goals					X
5. D-T-C Goals					X
6. RIW Considerations					X
7. Multi-National Considerations	X				
8. Annual Flying Hours		X			X
9. Number of Bases		X		X	X
10. Number of Aircraft		X		X	X
11. Crews per Aircraft	X	X	X	X	X
12. Crewmen per Crew	X	X	X	X	X
13. Crew Makeup	X	X	X	X	X
14. Missions		X		X	
15. Mission Essential Elements	X				
16. Performance	X	X			
17. Configuration	X	X	X	X	X
18. Construction	X	X	X	X	X
19. Expected Operational Life		X			X
20. Maintenance Probabilities		X	X	X	X
21. Maintenance Times		X	X	X	X
22. Skill Category		X	X	X	X
23. Skill Level		X	X	X	X
24. Crew Size		X	X	X	X
25. SE Utilization		X	X	X	X

Table 3-1

HUMAN RESOURCE TECHNOLOGY DATA

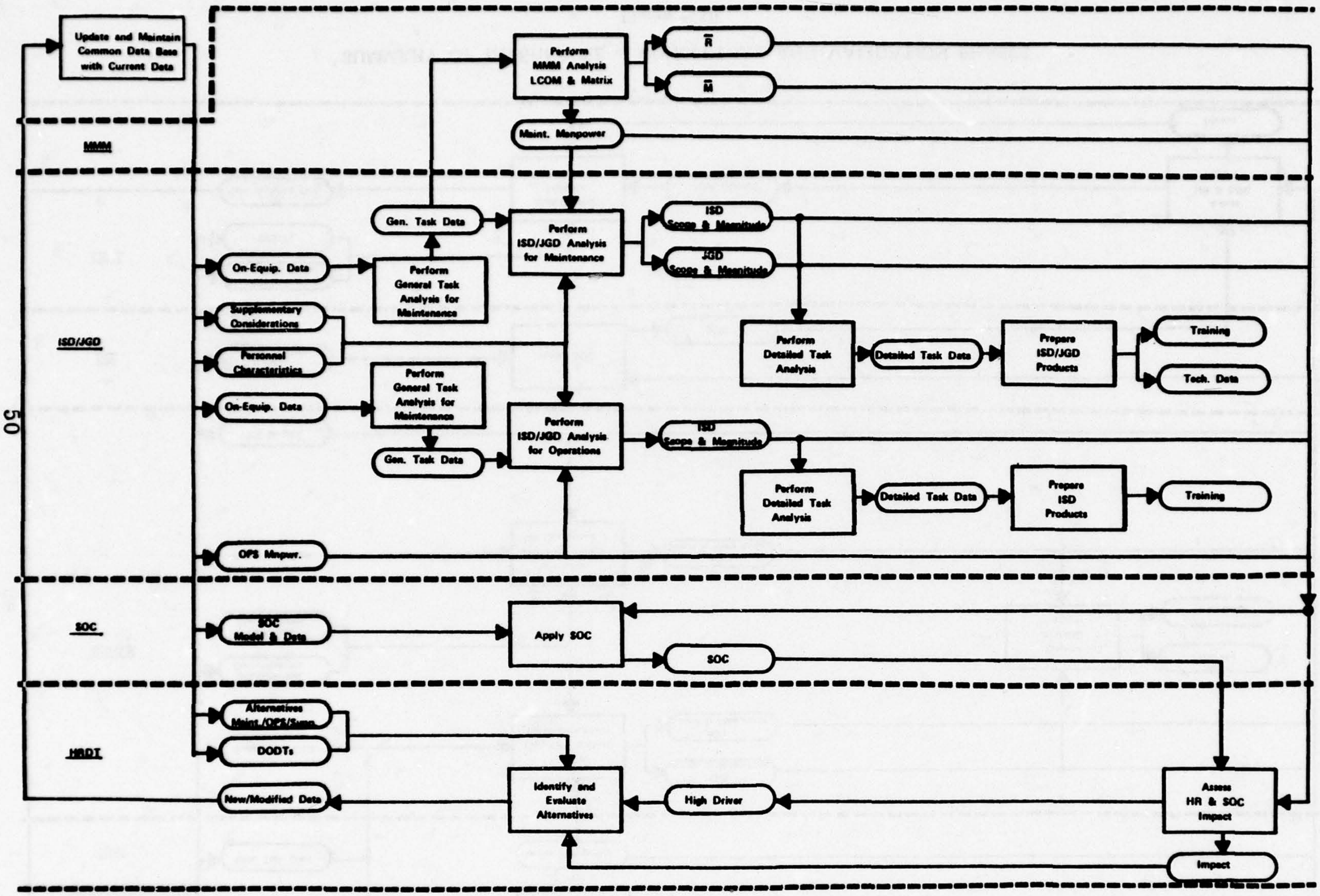
DATA ITEM	HRDTT	MMMT	JGDT	ISDT	SOCT
26. Safety Hazards	X	X	X	X	
27. Available Personnel					
a. Years of Service				X	X
b. Labor Rate					X
c. Scores			X	X	
d. Retention Rate			X	X	
e. Predictions			X	X	
28. Task Frequency			X	X	
29. Task Criticality			X	X	
30. Task Difficulty			X	X	
31. Degree of Proceduralization			X	X	
32. Content of Task Information			X	X	
33. Job Guide Concept			X	X	
34. Job Guide Status			X		
35. Manual Content			X		
36. Training Concept			X	X	
37. Training Status				X	
38. Course Content				X	
39. Time to Train				X	
40. Quantity to Train				X	X
41. Training Resources				X	X
42. Cost					
a. SE Investment			X		X
b. Manual Investment					X
c. LRU Spares Investment					X
d. Aircrew					X
e. Fuel					X
f. Depot Repairs					X
g. Facilities					X
h. Inventory					X
i. Technical Record Data					X
j. On/Off Equipment Maintenance					X
k. Training				X	X
l. Maintenance Material					X

Table 3-1
(continued)



'SUMMARY OF INTERFACES – CONCEPTUAL AND VALIDATION PHASES

Figure 3-10



SUMMARY OF INTERFACES – FULL SCALE DEVELOPMENT PHASE

Figure 3-11

Section 4

THE COORDINATED HUMAN RESOURCE TECHNOLOGY (CHRT)

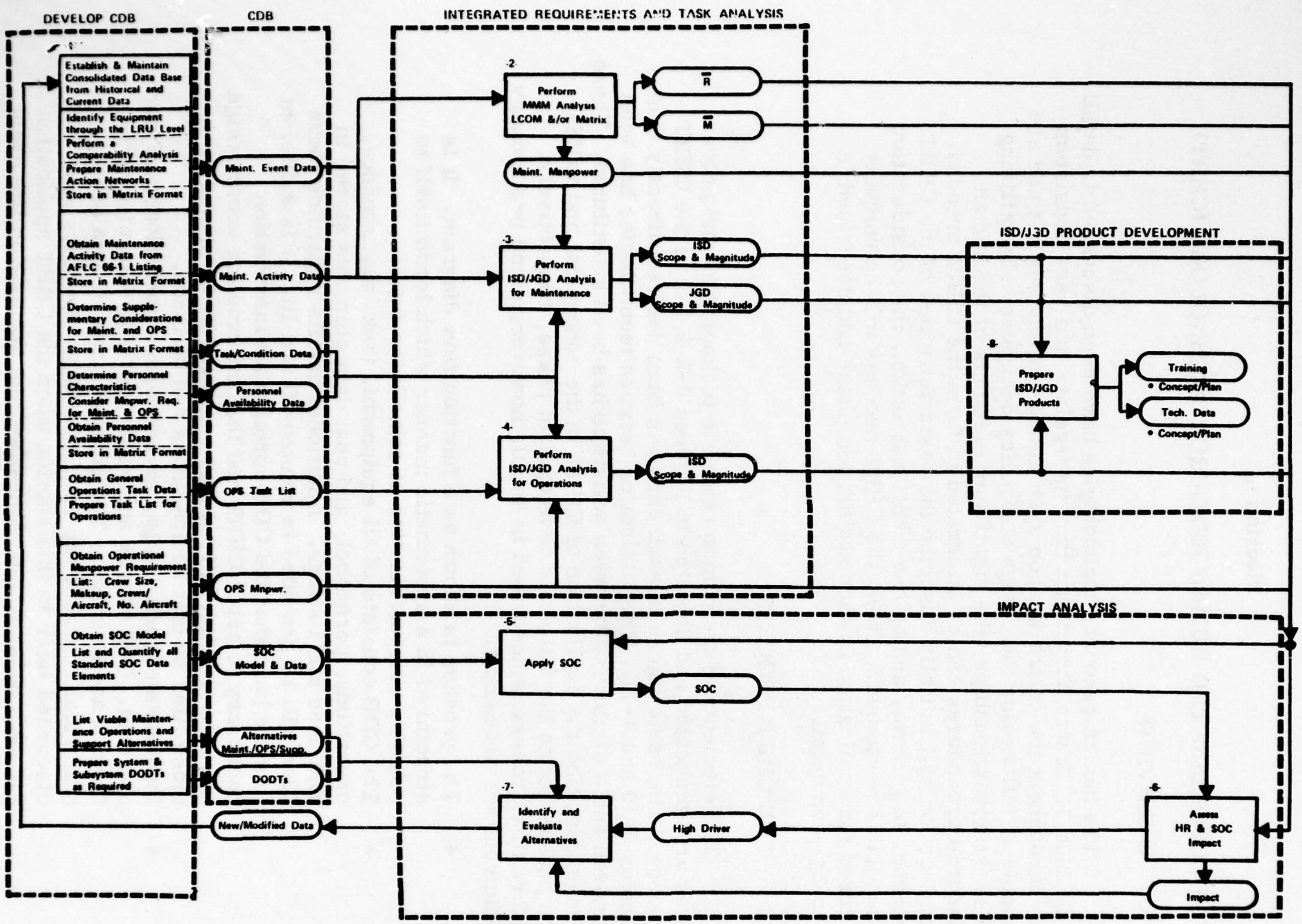
4.1 OVERVIEW

The human resource technologies have been discussed in detail in Section 3. It was shown that they interrelate in a very consistent way throughout the entire weapon system acquisition process and are capable of influencing the design and policy decisions. By utilizing these interrelationships, the significant elements of the human resource procedures can be integrated to form the CHRT process. This section will initially describe the basic activities of the CHRT process, in general, adding one additional action, the consideration of available personnel. Then, the CHRT process will be uniquely tailored for application in each acquisition phase and described in step-by-step detail.

4.2 THE CHRT PROCESS

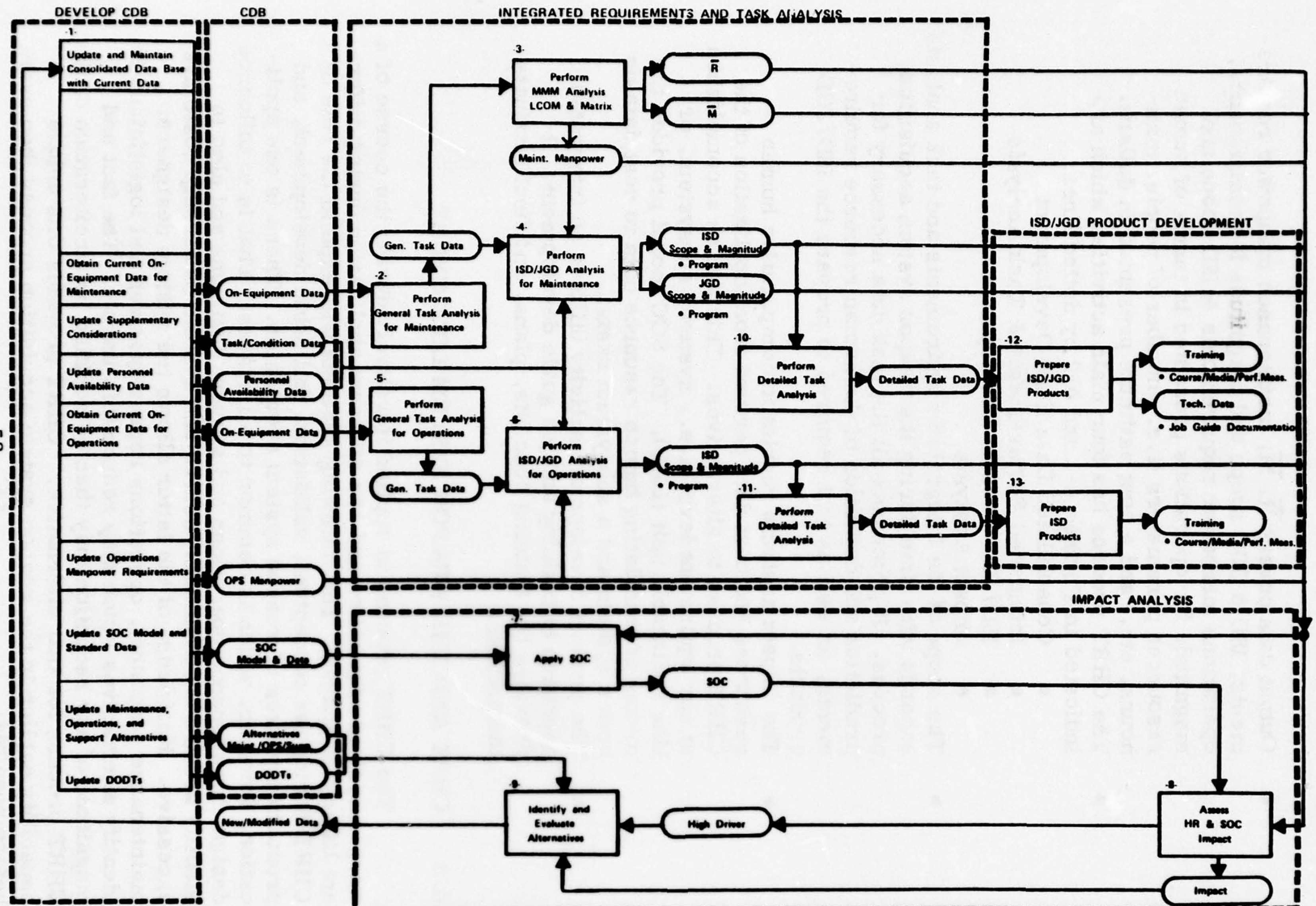
The elements of the human resource technologies and procedures are integrated and depicted in Figures 4-1 & 4-2 as the CHRT process. The basic figure in each case has been derived directly from Figures 3-10 and 3-11. The distinction between technologies has been removed and a distinction between activities has been substituted. These figures describe the application of CHRT in the conceptual and validation phases and in the full scale development phase, respectively. Before this process is described in detail, however, some preliminary comments are necessary.

- The process is shown as a function flow diagram. It is structured in a systematic manner which lends itself to possible computerization at some later date.
- The CDB consists of all equipment, task, maintenance, operations, personnel, and cost data elements stored in matrices and listings. Additional details regarding these files will be provided in volumes II and III. It is sufficient to state here that the CDB contains all information necessary to apply CHRT and that information about design and support alternatives may temporarily be stored in those files so that comparisons can be made.
- Input data covers design, maintenance, operations, support and cost. The source and validity of this data will vary from phase to phase. The general types of data are historical, current and new/modified. Specifics are discussed later in this section when the CHRT application for each phase of the weapon system acquisition life cycle is developed.



THE CHRT PROCESS (CONCPETUAL AND VALIDATION PHASE)

Figure 4-1



THE CHRT PROCESS (FULL SCALE DEVELOPMENT PHASE)

Figure 4-2

- Output data covers $\overline{R}$, $\overline{M}$, maintenance manpower requirements, ISD & JGD scope and magnitude for maintenance, operations manpower requirements & ISD scope and magnitude for operations presented in terms of human resources parameters (i.e., number of people, man-hours, etc.) and a cost estimate presented in dollars.
- The CHRT process has four main activities which are indicated in Figures 4-1 and 4-2 by dotted lines:
  - Consolidated Data Base Development
  - Integrated Requirements & Task Analysis
  - ISD/JGD Product Development
  - Impact Analysis
- The scope of the integrated requirements and task analysis expands with time during the weapon system acquisition process. It processes all the task data necessary for prediction and definition of the human resource requirements, as well as that required to prepare the ISD/JGD products.
- The impact analysis results in comparative human resources and cost data derived from application of the CHRT process to alternatives. This can be accomplished at any equipment level (i.e., system, subsystem, or line replacable unit (LRU). The SOC model provides the means of translating human resource data to cost data on both a system and a subsystem basis.
- The product development activity utilizes an integrated approach to training and job guide development. It provides the training concepts, plans, and final products themselves.

4.3 CHRT AND THE WEAPON SYSTEM LIFE CYCLE

The CHRT process is applied iteratively during the course of a weapon system acquisition and has different application during different life cycle phases. The following sections will explain the role of CHRT during the conceptual, validation, full scale development, and production phases of weapon system acquisition. There is one application, however, which is common to all phases. That is to influence design, maintenance operations and support decisions and also to identify areas where human resource and system ownership costs are excessive. Knowledge of the latter allows the system designers, maintenance personnel, operations representatives and logisticians to identify alternatives which may reduce this impact. The fact and magnitude of any reduction may then be verified by a reiteration of the CHRT process for that alternative. CHRT provides this unique capability earlier in the weapon system acquisition process then ever before possible.

CHRT in the Conceptual and Validation Phases

During the conceptual phase, the CHRT baseline and consolidated data base are established. Where current data is not available, historical data is used in order to fill the data base. A model for a reference system and each basic configuration is developed and a minimal task analysis is performed. The goals during this phase are to form concepts, identify major HR and cost impacts related to specific system design, maintenance, operations and support approaches, identify approaches within cost constraints, and identify risk areas. In concert with these goals, a baseline is established for the validation phase for each prototype configuration carried into that phase.

During the validation phase, CHRT is utilized to participate in the system/subsystem trade-off process between and within each specific configuration carried forward. More specific data is available during this phase and a more comprehensive task analysis is possible. Historical data, however, remains a prime source of information. The goals during the validation phase are to verify that all the HR "high burners" have been addressed, develop the support plan, develop a system specification, and revise estimates of system ownership costs. In concert with these goals, a very comprehensive CHRT model can be developed for the selected design.

The CHRT process for the conceptual & validation phases is depicted in Figure 4-1 and explained on a block-by-block basis in subsequent paragraphs. The ellipses on the flow diagrams represent the data obtained from the preceding action. This data is stored in the CDB. All blocks represent action. The prime input to this process is the best available historical or current operations, design, logistics, and cost data. As each action is discussed, the associated data will be described.

Block 1 - Establish and maintain the consolidated data base from historical and current data. The consolidated data base is the cornerstone of CHRT and is initially established for the basic configurations. Historical information is the prime source of data and is updated with current information as it becomes available. Most of the initial steps in each of the technologies are combined here to develop data needed for the integrated requirements and task analysis and the impact analysis. These will be described in more detail in Volumes II and III. Briefly, however, the individual events within this block are:

- Obtain general maintenance task data. This is accomplished using the steps required for the MMM comparability analysis and maintenance action networks. The general task data is stored in the maintenance event matrices of the CDB.
- Obtain supplementary task data. Through a knowledge of equipment comparability, supplementary task data is derived from Air Force Logistic Commands (AFLC) listings of AFM 66-1 data. This general task data is stored in maintenance activity matrices.
- Determine supplementary considerations. For maintenance, this information is derived from maintenance event data, maintenance activity data, interviews with maintenance personnel, comparable tech data and training resources. For operations, this data is drawn from operations and mission concepts and plans, operations requirements, comparable training courses and a review of existing training resources. This data is separated into maintenance and operational categories and is stored in task condition matrices.
- Determine personnel characteristics. Through a knowledge of maintenance and operational manpower requirements, data is obtained reflecting the characteristics of available personnel. This data is also separated into maintenance and operational categories and is sotred in personnel availability matrices.
- Obtain general operations task data. This is accomplished through a comparison of the mission for the proposed system with similar existing missions and a consideration of the expected crew size or makeup. This data is stored as an operational task list.
- Obtain operational manpower requirements. This is accomplished through a consideration of directed or proposed crew size, makeup, crews per operational aircraft ratio, and the number of operational aircraft proposed.
- Obtain SOC model list and quantification of all SOC standard data elements.
- List viable maintenance, operational, and support alternatives to be considered.
- Develop a system DODT and subsystem DODTs as required.

Block 2 - Perform MMM analysis. This is the first step of the integrated requirements and task analysis. The maintenance event matrices are equipment-oriented to the LRU level and are constructed from the data derived from the MMM comparability analysis and maintenance action networks. They describe the potential maintenance actions possible on each piece of equipment in terms of probability of occurrence, task time, skills, number of personnel to complete an action, and support equipment required. Manipulation of these matrices results in expeditious quantification of the system/subsystem maintenance requirements, maintenance manpower, $\overline{R}$ and $\overline{M}$. Data provided within this operation is also used to feed the LCOM simulation during the validation phase. The R&M model is used primarily during the conceptual phase, but also as a screening process for LCOM during the validation phase. For example, after the manpower requirement has been grossly determined and accepted, LCOM can then be used to verify and refine it.

Block 3 - Perform ISD/JGD analysis for maintenance. This is the second step of the integrated requirements and task analysis. This activity integrates the maintenance event, maintenance activity, task/condition, personnel availability and maintenance manpower requirement data. A maintenance task intensity profile is established and the scope and magnitude of the maintenance ISD and JGD program are predicted.

Block 4 - Perform ISD/JGD analysis for operations. This is the third step of the integrated requirements and task analysis. This activity integrates the operations task list, task/condition, personnel availability, and operations manpower requirement data. An operations task evaluation is made and the scope and magnitude of the operation ISD program is predicted. A JGD program is probable but minimal.

Block 5 - Apply SOC equations. The human resources parameters; $\overline{R}$, $\overline{M}$, maintenance manpower, maintenance ISD/JGD scope and magnitude, operations ISD scope and magnitude, and operations manpower are applied to the SOC model and an estimate is made.

Block 6 - Assess HR & SOC impact. This is the first step of the impact analysis. The configuration for which the human resources are defined and for which SOC is applied represents weapon system characteristics and support goals permanently or tentatively established in the CDB. The design itself is reflected in a design option decision tree which also identifies those design decision points where options have been or need to be identified.

At this point the alternative in question is evaluated relative to both cost and effectiveness. The human resource impact and cost impact are recorded in the CDB. Should this impact be acceptable, the weapon system characteristics, support goals, and DODTs are updated as necessary. Should this impact be unacceptable, Block 7 is entered. At this point too, the alternative design in question is reviewed for high drivers. Specifically, these are subsystems and/or LRUs that consume excessive human resources (i.e., excessive failure rates, maintenance times, manning, training, or job guide support). "Excessive" is a judgemental factor and may be an established screening level or a judgement resulting from a review of the existing data.

Block 7 - Identify and evaluate alternatives. This is the second step of the impact analysis. Should the impact be unacceptable or should a high driver be determined, alternative maintenance, operations or support approaches may be identified from the CDB listing or an alternative design may be identified from the appropriate DODT. New or modified data is then established in the CDB and the CHRT process reiterated to evaluate its effect.

Block 8 - Prepare ISD/JGD products. The ISD/JGD scope and magnitude for viable configurations is expanded and developed into the training and tech data concepts or plans, as appropriate.

CHRT in the Full Scale Development Phase

During the full scale development phase, CHRT is utilized to support the detailed design effort. Current data from alternative detail designs may be evaluated for HR impact and the basic design surveyed for HR high burners. Additionally, a coordinated set of ISD & JGD products is produced from an integrated task analysis.

The goals during full scale development are (a) to arrive at a design with acceptable HR requirements, (b) to accurately predict SOC, and (c) to develop a coordinated and appropriate training program and tech data.

The CHRT process in the full scale development phase is depicted in Figure 4-2 and explained on a block-by-block basis below. The ellipses on the flow diagrams represent the data obtained from the preceding action. This data is stored in the CDB. All blocks represent action. The prime input to this process is the best available historical or current operations, design, logistics, and cost data. As each action is discussed, the associated data will be described.

Block 1 - Update and maintain the consolidated data base with current data. This is essentially an updating effort with one major exception being the tabulating of on-equipment data for both maintenance and operations. The on-equipment data reflects the latest hardware configuration and results of all tests and evaluations. This on-equipment data feeds the integrated task analysis and eliminates the previous requirements for maintenance event data, maintenance activity data, and an operations task list.

Block 2 - Perform a general task analysis for maintenance. This step results in task-related data to the LRU level and is comparable in depth of content to that previously obtained from the MMM comparability analysis and maintenance action networks. The resulting task data now is based on the actual hardware, however, rather than comparable items.

Block 3 - Perform the MMM analysis. The use of the R&M model is still applicable in the full scale development phase for determining $\bar{R}$ & $\bar{M}$ and for screening maintenance manpower. The LCOM simulation, however, becomes the primary tool for determining maintenance manpower requirements now that alternatives are limited and significant on-equipment data is available.

Block 4 - Perform ISD/JGD analysis for maintenance. This effort is now based on realistic maintenance manpower requirements verified by LCOM and an integrated task analysis performed on-equipment and derived with traditional methods. Updated task/condition and personnel availability data contribute to its validity.

Block 5 - Perform a general task analysis for operations. An on-equipment task analysis based on the most current operations requirements and crew data is accomplished in coordination with that performed for maintenance. This effort results in sufficient data to define the ISD program for the operator.

Block 6 - Perform ISD/JGD analysis for operations. The general task data is used to define the ISD program for the operator as well as any operations related job guides. The need for maintenance related job guides for the operator is determined as part of the ISD/JGD analysis for maintenance.

Blocks 7, 8, and 9 are accomplished in the same manner as during the conceptual and validation phases except the alternatives are now at a more detailed level and estimates are more accurate because current data is used.

Blocks 10 & 11 - *Perform detailed task analysis.* This is the final step of the integrated task analysis which provides all information necessary for both training and tech data development and it is coordinated between maintenance and operations. Some additional training/job guide trade-offs may be determined and implemented at this stage. These trade-offs will not be at a level, however, which will significantly affect the ISD/JGD scope and magnitude determined in Blocks 4 and 6.

Blocks 12 & 13 - Prepare ISD/JGD products. The products of full scale development are training course, training media, performance measurements and job guide documentation.

CHRT in the Production/Deployment Phase

During the production phase, CHRT can be utilized to assess the effect of engineering changes and equipment modifications on HR. The CDB will have been updated as a result of full scale development phase demonstrations and is maintained current with the usage data that becomes available.

The goals in this phase are to identify and evaluate areas where production and field data disagree with CHRT estimates.

The final production phase CDB can be transitioned with the system and used throughout the remaining system life to evaluate the effect of equipment or policy changes.

Conclusion

CHRT is applicable and workable in all phases of weapon system acquisition. Throughout acquisition, but especially during the conceptual phase, CHRT can significantly influence design, maintenance, operations and support decisions by making the human resource impact of such a decision known. The process is essentially the same for all phases except for the integrated task analysis which is drawn from current on-equipment data in full scale development and provides the input to MMM rather than using the MMM comparability analysis and maintenance action networks previously derived from historical data.

This volume explained the CHRT process in detail and further identified the various basic activities associated with it. In the next volume, Volume II, the basic activities associated with the CHRT process will be brought out in detail.

ABBREVIATIONS AND ACRONYMS

The following abbreviations and acronyms are used with the CHRT.

A	availability
A/C	aircraft
AFHRL	Air Force Human Resources Laboratory
AFSC	Air Force specialty code
AMST	Advanced Medium STOL Transport
ATIM	annotated task identification matrix
CDB	consolidated data base
CND	cannot duplicate
CHRT	coordinated human resource technology
DSARC	Defense Systems Acquisition Review Council
FOMM	functionally organized maintenance manuals
FPJPA	fully proceduralized job performance aids
HRDT	human resources in design tradeoffs
ILS	integrated logistic support
ILSP	integrated logistic support plan
IRTA	integrated requirements and task analysis
ISD	instructional system development
JGD	job guide development
JPA	job performance aid
LCC	life cycle cost
LCOM	logistic composite model
LSA	logistic support analysis
LSAR	logistic support analysis record
$\overline{M}$	maintainability
MFHBMA	mean flight hours between maintenance actions
MMH/FH	maintenance man hours/flight hour
MMM	maintenance manpower modeling
MTTR	mean time to repair
NRTS	not repairable this station
PTIM	preliminary task identification matrix
$\overline{R}$	reliability
ROC	required operational capability
SIMM	symbolic integrated maintenance manuals
SOC	system ownership cost
STOL	short field takeoff and landing

DEFINITIONS

The following definitions are applicable to CHRT.

algorithms - mathematical formulas and procedures, pre-programmed into the system, which will translate data from base files and/or sub-files into data elements which quantify human resource requirements and ownership cost.

baseline data - data which reflects the weapon system approved for further development at a DSARC milestone.

background data - all weapon system program data from which CDB data is drawn.

behavior - any human action generally defined by a stimulus (cue) and response. A basic stimulus-organism-response constituent of behavior comprising the smallest logically defineable set of perceptions, decisions, and responses required to complete a task. Involves, for example, identifying a specific signal on a specific display, deciding on a single action, activating a specific ontrol, and noting the feedback signals of response adequacy.

cue - a stimulus to a response. For example, a cue could consist of a meter reading, physical appearance, flashing light, etc. Responses to cues consist of such activities as turning a knob, setting a switch, reading a value on a display, etc. Often a response can be a cue for a succeeding response.

current data - data which reflects the updated and accepted weapon system configuration at any specific time between the baseline of each phase.

data base - a grouping of base files by category (or defined set) representing all the basic data for a specific generation of equipment.

data element - a grouping of information and units which has a unique meaning and which may have subcategories (data items) of distinct units or values.

data element definition - a narrative definition of the data element in sufficient detail to present a clear and complete understanding of the precise data or element of information that the data element represents.

detailed task data - task statements to the level required to make the final ISD/JGD decision, to make tradeoffs within the instructional system itself and finally to develop the products; course, media, performance measurement, and job guide documentation.

extended -11 file - the format used by the Logistics Composite Model (LCOM) to identify the maintenance tasks and the order in which they are to be done, along with the time and resources needed to accomplish each task.

file - a grouping of one type of input variable or a derived quantity thereof for a particular ID. All of the input data items are grouped for a comparable level (e.g., flightline, shop).

job - a group of tasks performed by a specific individual.

general task data - task statements to the level required to make a basic decision regarding manpower requirements and the applicability of training courses, media, performance measurement and job guides documentation (i.e., the ISD/JGD decision). For maintenance, the task level would be to the LRU (e.g., repair LRU) but would not include development of the specific task statements that encompassed the task.

line replaceable unit (LRU) - a combination of parts, subassemblies, and assemblies mounted together, normally capable of independent operation in a variety of situations. An LRU is normally directly accessible and can be removed without prior disassembly of the equipment or group. (MIL-STD-280). The LRU is the first level of assembly below the subsystem that is carried as a line item of supply at the base level and is usually the highest level of assembly that is removed and replaced, as a unit, on the flightline.

maintenance event - consists of one or more maintenance functions. These maintenance events are specifically symbolized and identified as:

A - setup support equipment
T - troubleshoot on aircraft (A/C)
C - cannot duplicate (CND) on A/C
M - minor repair on A/C
R - remove & replace (R&R)
V - verification of $\overline{\text{R}}$ or $\overline{\text{M}}$ events
W - bench check and repair in shop
K - bench check and CND in shop
N - not repairable this station (NRTS)
H - scheduled checks, inspections, or service

maintenance function - a behavioral term associated with a task. Specifically: adjust, align, calibrate, checkout, troubleshoot, clean, disassemble/assemble, inspect, lubricate, operate, remove/install, repair, service are maintenance functions (ref. AFHRL-TR-73-43(I)).

reference data - data which reflects a reference weapon system. The reference system is the system(s) that the new acquisition will specifically replace and consequently must be shown to be less cost/ effective in the long run. Reference data is compiled in the conceptual phase and retained as a supplement to the CDB. It would not be expected to change since it is normally derived from operations, performance, support, and cost information on existing systems. In some cases there may be no reference system(s).

shop replaceable unit (SRU) - the SRU is a lower level assembly or subassembly within an LRU normally formed together to perform a specific function. An SRU is normally repaired or replaced only within the base (intermediate level) shops rather than on the flight line.

skill level - the fourth number within an AFSC identifying a level of aptitude, training, experience, knowledge, skills, and responsibility.

subsystem - a set or combination of LRUs and/or assemblies generally physically separated when in operation connected together or used in association to perform an operational function within the system. It is the level of equipment identified by three characters in the work unit code structure (e.g., 7]B TACAN set) or as a four-digit ID number (e.g., AN/2 TACAN).

system - a major subset of a weapon system comprised of individual functional groupings and their integration within the weapon system (e.g., avionics, landing gear, electrical, etc.).

task - a composite of related activities (behaviors) performed by an individual and directed toward accomplishing a specific amount of work within a specific work context. These activities usually occur in temporal proximity with the same displays and controls and have a common purpose. Each task has a goal.

task analysis - an analytic process employed to determine the specific behaviors required of a human component in a man-machine system. It involves determining, usually on a time basis, the detailed performance required of men, the nature and extent of their interactions with the machine and the effects of environmental conditions and malfunctions. It is the breakdown of behaviors into simple elements of perceptions, decisions, memory storage, motor output, etc.

task statement - a statement of the behavioral elements (in action verb form), the cues, and equipment description involved in a task.

weapon system - a complete system including all equipment, related facilities, material software, services, and personnel required for its operation and support to the degree that it can be considered a self-sufficient unit in its intended operational environment (AFSC DH1-1 pg. 7, Section 25).

BIBLIOGRAPHY

The following documents were utilized in the development of the CHRT process.

1. AFIT, School of Systems and Logistics, "Acquisition Logistics, Current Readings and Lesson Plans." July 1977.
2. Air Force Manual 25-5. "Management Engineering Policies and Procedures." Washington, D. C. : Department of the Air Force, 8 August 1973.
3. Air Force Manual 26-3. "Air Force Manpower Standards." Washington, D. C. : Department of the Air Force, 27 February 1973.
4. Air Force Manual 50-2. "Instructional Systems Development." Washington, D. C. : Department of the Air Force, December 1970.
5. Air Force Manual 66-1. "Maintenance Management Policy." Washington, D. C. : Department of the Air Force, 1 August 1972.
6. Air Force Pamphlet 50-58. "Handbook for Designers of Instructional Systems." Washington, D. C. : Department of the Air Force, January 1974.
7. Air Force Regulation 173-7, "Formal Training Cost Analysis Report," HAF-ACM (A) 7108, Department of the Air Force, Washington, D. C.
8. Air Force Test and Evaluation Center, Cost of Ownership Handbook, Kirtland Air Force Base, New Mexico.
9. Air Training Command, ATC Cost Factors Summary, Randolph Air Force Base, Texas. (For Official Use Only.)
10. Askren, William B., and Korkan, Kenneth D., Design Option Decision Trees: A Method for Relating Human Resources Data to Design Alternatives. AFHRL-TR-71-52, December 1971, Wright-Patterson AFB, Ohio, AD741 768.
11. Askren, William B., "Human Resources and Personnel Cost Data in System Design Tradeoffs," AFHRL-TR-73-46, October, 1973, paper presented at 1973 annual meeting of the American Psychological Association, Wright-Patterson AFB, Ohio, AD770 737.

12. Askren, William B., Korkan, Kenneth D., and Watts, George W. Human Resources Sensitivity to System Design Tradeoff Alternatives, AFHRL-TR-73-21, November 1973, Wright-Patterson AFB, Ohio. AD776 775.

13. Askren, William B., and Korkan, Kenneth D., Design Option Decision Tree: A Method for Systematic Analysis of Design Problems and Integration of Human Factors Data, AFHRL-TR-75-9, July 1975, Wright-Patterson AFB, Ohio, and Proceedings, Human Factors Society, 18th Annual Meeting, October 1974.

14. Arzigian, S., Methods and Problems and Computation of Enlisted Personnel Costs, Naval Personnel Research and Development Laboratory, February 1964, RS-64-16, (AD803 758).

15. Baran, H. A., Air Force Human Resources Laboratory Military Personnel Costing Conference. Air Force Human Resources Laboratory, December 1974, AFHRL-TR-74-106, (AD A013 171).

16. Betague, N. S., Jr., Aircraft System Operating and Support Costs: Guidelines for Analysis, Logistics Management Institute, March 1977.

17. Cream, B. W., "A Functional Integrated Systems Trainer for Individual and Crew Coordination Training." Proceedings of the Fourth Annual Symposium on Psychology in the Air Force, 1974.

18. Cream, B. W., Eggemeier, F. T., & Klein, G. A., "Behavioral Data in the Design of Aircrew Training Devices." Proceedings of the Human Factors Society, 1975.

19. Czuchry, A., Glasier, J., Kistler, R., Bristol, M., Baran, H., and Dieterly, D., Digital Avionics Information System (DAIS) Reliability and Maintainability Model, AFHRL-TR-78-2, 1978.

20. Department of Defense, "Life Cycle Costing Procurement Guide (Interim)," LCC-1, July 1970, Washington D. C.

21. Department of Defense, "Casebook Life Cycle Costing in Equipment Procurement," LCC-2, July 1970, Washington, D. C.

22. Department of Defense, "Life Cycle Costing Guide For System Acquisition (Interim)," LCC-3, to be published, Washington, D. C.

23. Department of Defense Directive 5000.1, "Major System Acquisitions." Department of Defense, Washington, D.C., 18 July 1977

24. Department of Defense Directive 5000.2, "Major System Acquisition Process," Department of Defense, Washington, D.C., 18 January 1977.

25. Department of the Navy, "Annual Training Time and Cost for Navy Ratings and NECs," (FY 73 Edition). Bureau of Naval Personnel, November 1972, NAVPERS-18660.

26. Department of the Navy, "Navy Military Manpower Billet Cost Data for Life Cycle Planning Purposes." Personnel Research Division, Bureau of Naval Personnel, April 1972, NAVPERS-15163.

27. Drake, W. F., et al. Logistics Composite Model Users Reference Guide. Air Force Logistics Command Report 70-1, AD703 328. Headquarters Air Force Logistics Command, January 1970.

28. Eckstrand, Gordon A., Askren, William B., and Snyder, Melvin T. "Human Resources Engineering: A New Challenge," Human Factors, 1967, 9(6), 517-520.

29. Fisher, G. H. "Cost Considerations in Systems Analysis" Rand Report, R-490-ASD, December 1970.

30. Foley, J. P., Jr., Task Analysis for Job Performance Aids and Related Training. AFHRL-TR-72-73. Wright-Patterson AFB, OH: Air Force Human Resources Laboratory, November 1973. AD-771 001.

31. Foley, J. P., Jr., A Proposed Modified Technical Order System and Its Impact on Maintenance, Personnel and Training. AFHRL-TR-75-82. Wright-Patterson AFB, Ohio: Air Force Human Resources Laboratory, December 1972. AD-A022 252.

32. Foley, J. P., Jr., Some Key Problems Concerning the Specification Development and Use of Task Identification and Analysis, AFHRL-TR-76-57, Wright-Patterson AFB, OH, AFHRL, July 1976. AD-A029 199.

33. Gay, R. M. and Nelson, G. R., Cost and Efficiency in Military Specialty Training, The Rand Corporation, January 1974, P-5160.

34. Hicks, V. B., and Tetmeyer, D., Data Base Management Programs. AFHRL-TR-74-97(IV). Wright-Patterson AFB, OH: Advanced Systems Division, Air Force Human Resources Laboratory, December 1974. AD-A011 989.

35. Joyce, R. P., Chanzott, A. P., Mulligan, J. F., and Mallory, W. J., Fully Proceduralized Job Performance Aids: Volume I - Draft Military Specification for Organization and Intermediate Maintenance. AFHRL-TR-74-43(I), AD775 702. Wright-Patterson AFB, OH: Air Force Human Resources Laboratory, December 1973.

36. Joyce, R. P., Chanzott, A. P., Mulligan, J. F., and Mallory, W. J., Fully Proceduralized Job Performance Aids: Volume II - Handbook for JPA Developers. AFHRL-TR-73-43(II). AD775 705. Wright-Patterson AFB, OH: Air Force Human Resources Laboratory, December 1973.

37. Joyce, R. P., Chenzott, A. P., Mulligan, J. F., and Mallory, W. J., Fully Proceduralized Job Performance Aids: Volume III - Handbook for JPA Managers and Training Specialists. AFHRL-TR-73-43(III). AD775 706. Wright-Patterson AFB, OH: Air Force Human Resources Laboratory, December 1973.

38. Katz, I., "Project ABLE (Acquisition Based on Consideration of Logistic Effects)," Operations Analysis Report No. 8, May 1969, Hq. Air Force Logistics Command.

39. Lintz, Larry M., Askren, William B., and Lott, Wayne J., System Design Trade Studies: The Engineering Process and Use of Human Resources Data, AFHRL-TR-71-24, June 1971, Wright-Patterson AFB, Ohio, AD732 201, and Human Factors, February 1975.

40. "Logistic Support Analyses," MIL-STD-1388-1, 15 October 1973.

41. "Logistic Support Analysis Data Element Definitions," MIL-STD-1388-2, 15 October 1973.

42. Maher, F. A., and York, M. L., Maintenance Manpower Management During Weapon System Development. AFHRL-TR-74-97(I). Wright-Patterson AFB, OH: Advanced Systems Division, Air Force Human Resources Laboratory, December 1974. AD-A011 986.

43. "Manuals, Technical: General Style and Format Requirements," MIL-M-3878-4.

44. "Manuals Technical: Front End Analysis," MIL-M-63035(TM) 1 May 1977.

45. "Manuals Technical: Operators, Preparation of," MIL-M-63036(TM), 1 May 1976.

46. "Manuals Technical: Organizational Direct Support, and General Support Maintenance (ITDT - Flow Chart)," MIL-M-63037(TM), 1 May 1977.

47. Military Airlift Command, "Required Operational Capability, AMST," ROC 9-75, 25 February 1977.

48. Moody, W. D., Nichols, S. R., and Tetmeyer, D. C., Manpower Program, AFHRL-TR-74-97(V). Wright-Patterson AFB, OH: Advanced Systems Division, Air Force Human Resources Laboratory, 1975. AD-A011 990.

49. Mullen, P. A., and Joyce, R. P., Demonstration of Fully Proceduralized Job Performance Aids and Matching Training. AFHRL-TR-74-69, AD A002 147. Wright-Patterson AFB, OH: Air Force Resources Laboratory, August 1974.

50. Nichols, S. R., Deem, R. N., Tetmeyer, D. C., Maintenance Data Analysis Programs. AFHRL-TR-74-97(III). Wright-Patterson AFB, OH: Advanced Systems Division, Air Force Human Resources Laboratory, 1975. AD-A025 342.

51. Tetmeyer, D. C., Estimating and Controlling Manpower Requirements for New Systems: A Concept and Approach. AFHRL-TR-74-31, AD 778 838. Wright-Patterson AFB, OH.: Advanced Systems Division, Air Force Human Resources Laboratory, April 1974.

52. Serendipity, Inc., Project PIMO Final Report. TR-69-155, Volume I, AD 852 101. Space and Missile Systems Organization, Air Force Systems Command, Norton AFB, CA, May 1969.

53. Stratton, A., "The Principles and Objectives of Cost-Effectiveness Analysis," The Aeronautical Journal of the Royal Aeronautical Society, Vol. 72, No. 685, January 1968, pp. 43-53.

54. Whalen, Gary V., and Askren, William B., Impact of Design Trade Studies on System Human Resources, AFHRL-TR-74-89, December 1974, Wright-Patterson Air Force Base, Ohio. AD-A009 639.

★U.S. GOVERNMENT PRINTING OFFICE: 1978-771-122/15